Design of Two-wheeled Vertical Intelligent Balancing Robot Control System Based on S08 Microcontroller

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Abstract: Two-wheeled vertical intelligent balancing robot is applicable to many complex working environments, and has high practical value and theoretical value. MC9S08AW60 microcontroller is used as the core controller in the balancing control system of the two-wheeled vertical robot. MMA7260 and SCA610-CA1H1G are used to detect the tilt angle and angular rate of the robot body. The bridge driving circuit L298N is used to drive the micro DC motor with PWM control technology, and the photoelectric code disc is used to detect the speed of the motor.

1. Introduction

With the rapid development of science and technology, human beings have entered the era of digitalization and intellectualization. The development of computer science and control theory makes it possible for human beings to manufacture highly intelligent simulation robots. Mobile robot is an important branch of modern robots. It can move to a specific location independently according to the specified commands. It has the functions of perception and self-adaptation of the working environment, real-time decision-making of motion and control of its own behaviour. It has high military and commercial value [1]. Wheeled mobile robot is an important branch of mobile robot. Wheeled mobile robots are more suitable for working in narrow and large turning situations, so the practical and theoretical value of wheeled mobile robots is very high [2].

2. Overall design plan

2.1. Major component

Two-wheeled vertical intelligent balancing robot can be divided into mechanical system and control system according to its motion characteristics. The control system mainly includes motor, driving circuit, attitude detection system, power supply circuit and MCU controller. This design mainly studies the control system of intelligent balancing robot. Its main task is to detect the angle and angular velocity of the tilting body of the robot, as well as the speed and steering of the DC motor, and to adjust the speed of the robot to achieve the balancing control of the robot system [3].

2.2. Scheme analysis of robot balance control system

The balance control system is designed according to the dynamics and kinematics analysis of the two wheeled upright intelligent robot. The S08 microcontroller is used as the core controller in the balance control system of the two-wheeled upright intelligent robot. The attitude sensor is composed of inclination sensor and acceleration sensor to detect the inclination angle and dumping rate of the vehicle body platform. The speed of the robot is measured by photoelectric encoder. PWM pulse width modulation technology is used to control DC motor. The detection output of the attitude sensor is transmitted to the controller by the feedback signal. According to the feedback signal, PID control algorithm is used to adjust the duty cycle of the PWM pulse width of the controller output, so as to change the speed of the servo motor to achieve the system balance.

3. Microcontroller and detection circuit design

3.1. Main technical parameters of S08 microcontroller

The 8 bit MC9S08AW60 microcontroller of Freescale semiconductor has good working ability, of which minimum system circuit diagram is shown in Fig.1. The processor has up to 40 MHz CPU clock frequency and 20 MHz internal bus frequency, working voltage is 4.5V to 5.5V, and the temperature range is - 40 C to 85 C. There are up to 32 interrupt / reset sources. Up to 62KB on chip programmable Flash memory, with module protection and security options.

The security circuit prevents unauthorized access to memory and flash content. There are two kinds of power saving modes and a wait saving mode. The clock to maintain specific peripheral mode is allowed and external oscillator (XOSC) can be connected. The low frequency range of crystal or ceramic resonators is 31.25 KHz to 39.0625 KHz, and the high frequency range is 1 MHz to 16 MHz. The processor has a watchdog reset, the microcontroller works normally reset option dedicated to 1 kHz internal clock source and clock bus. When the I/O pin is used as the input, the software can select the pull up resistor. When the output is used, the strong / weak driving ability and the slew rate can be selected by software.

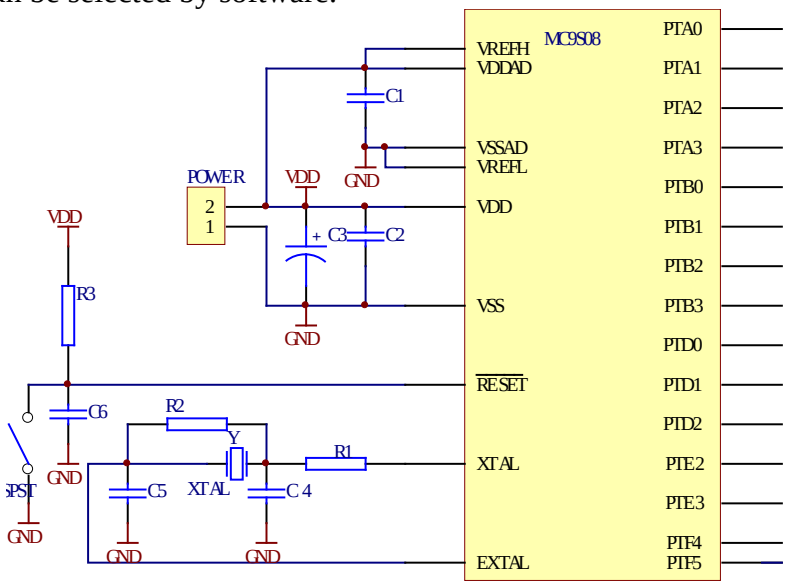

Fig.1 MC9S08 microcontroller minimum system circuit diagram

3.2. Angle and angular velocity detection module

The acceleration sensor MMA7260 adopts signal conditioning, unipolar low pass filter and temperature compensation technology. The device has low-pass filter and 0g compensation, provides sleep mode, low power consumption, stable performance and strong anti-vibration ability [4]. It is ideal for battery powered wireless data acquisition.

SCA610-CA1H1G tilt angle sensor is a gyroscopic tilt angle sensor, which is designed and manufactured by VTI Company, using capacitive 3D-MEMS technology. The sensor has high stability and high precision [5]. Its single supply voltage is + 5V, the analog voltage output range is 4.75 V ~ 5.25 V, and the measurement range is + 1 g (+ 90 degrees). The eight pin of the sensor is plastic surface mount package, which can enhance its failure detection function. In addition, it also has the function of digital activated electrical self-detection, parity check of correction memory and continuous connection failure detection. The frequency response of sensing components is controllable, compatible with ROHS standard, and supports lead-free soldering. The tilt angle and angular velocity of the robot body are directly output by SCA610-CA1H1G. The angular velocity can be derived from the angular information differential. The angular velocity and angular velocity can be compensated and corrected according to the output of MMA7260, so that accurate and stable angular velocity and angular information can be obtained. Considering comprehensively, this design chooses angle detection sensors composed of MMA7260 and SCA610-CA1H1G, of which

wiring diagrams are shown in Fig.2 and Fig.3.

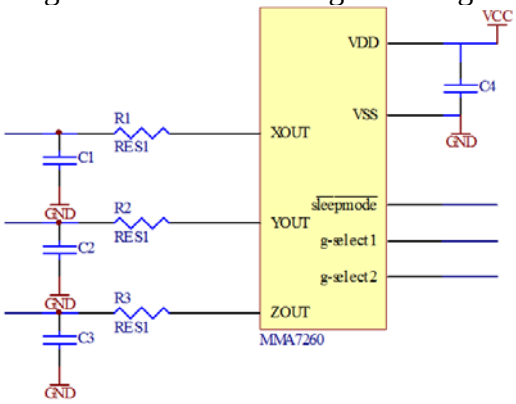

Fig.2 MMA7260 typical wiring diagram

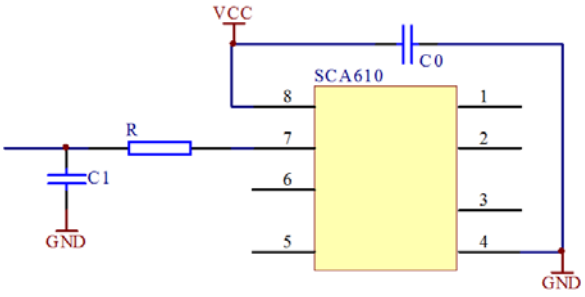

Fig.3 SCA610-CA1H1G wiring diagram

The attitude angle detection system of the two-wheeled vertical robot is mainly composed of accelerometer MMA7260, inclination sensor SCA610-CA1H1G, S08 microcontroller and filter circuit. The output of SCA610-CA1H1G and MMA7260 are sampled by microprocessor S08 at high speed A/D, and the tilt angle and angular velocity data are processed and compensated. Accelerometer MMA7260 compensates and corrects the inclination sensor SCA610-CA1H1G to get accurate attitude angle signal, and then obtains the angular velocity of the system by differential. This position information is calculated by PID controller, and then outputs PWM signal to control the motor .

Speed sensor. The speed sensor uses a photoelectric encoder fixed on the output shaft of the DC motor, as shown in Fig.4. Because the photoelectric code disc outputs digital pulse signals, these pulse signals can be directly connected to the counter port of the microcontroller S08. Each photocell outputs two pulse signals, and the speed of the motor is obtained by detecting the frequency of one pulse signal through the counter of S08. Because the output pulse waveform of the two is the same, the phase difference is 90 degrees. If the motor is rotating, the second pulse is 90 degrees behind. If the motor reverses, the second pulse is 90 degrees ahead. Therefore, the positive and negative rotation of the motor can be judged.

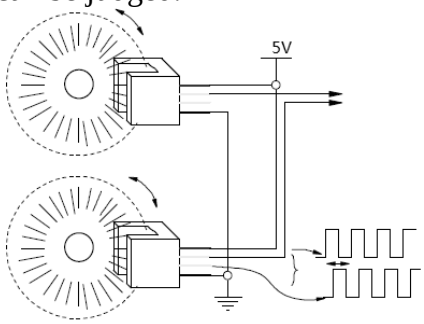

Fig.4 Photoelectric encoder speed measuring circuit

4. Driving circuit and power module design

The efficiency of micro DC motor is generally higher than that of other types of motor, and the size of DC motor is generally smaller under the same output power. It can be used in limited space. The micro DC motor can adjust speed automatically according to the load size to achieve great starting torque. It is very difficult for AC motors to realize this function. In addition, DC motor is easy to absorb the sudden change of load size, and motor speed can automatically adapt to the fluctuation of load size. The micro DC motor is easy to connect with the computer and is controlled by PWM technology.

Although brushless DC motor has no mechanical brush, its output torque is proportional to current, speed is proportional to voltage, and back EMF is proportional to motor speed, so its control characteristics and mechanical characteristics are basically the same as ordinary DC motor.

But the control system of brushless DC motor is complex, so the micro DC motor is used as the power system for the two-wheeled vertical robot. The circuit of DC motor driven by L298N is shown in Fig.5. The output terminals OUT1 and OUT2 are used to drive DC motors.

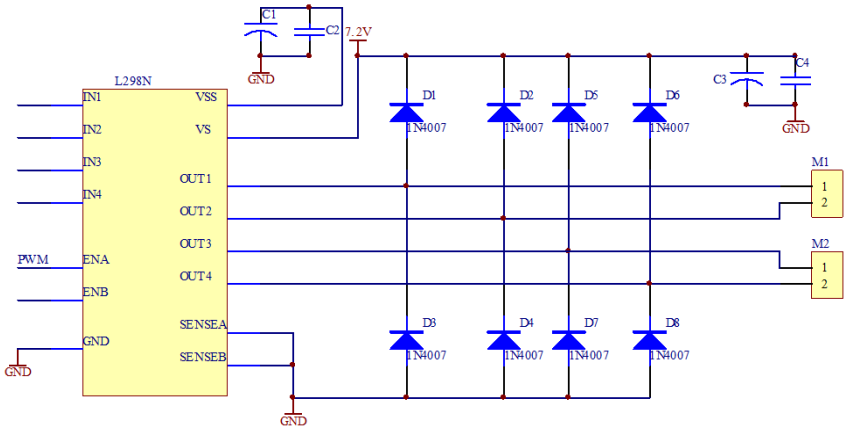

Fig.5 Circuit diagram of L298N driving micro DC motor

The power supply used by the intelligent vertical robot is connected by six batteries of the same type in series, and 7.2V and 2A/h rechargeable batteries are provided. The DC motor is directly powered by 7.2V batteries. Although S08 microcontroller system, attitude sensor module and photoelectric code disk all need 5V power supply, but S08 microcontroller system requires stable power supply, small ripple and good linearity, so LM2940 voltage regulator circuit is selected to supply power separately. The Sensor Module requires a larger current supply, and the power supply has a higher linearity. If the conversion efficiency is high and the load capacity is strong, the LM2596 voltage regulator circuit is selected to supply power. Using LM2940 to supply power to S08 microcontroller system and LM2596 to supply power to detection module can effectively prevent interference between devices and insufficient current, so that the system can work steadily.

5. Conclusion

Robot technology has gradually formed a relatively systematic scientific system, which integrates mechanics, mechanics, electronics, sensor technology, computer technology, control theory and algorithm, and constantly absorbs the latest research results of other related disciplines, forming an independent high-tech discipline. Combining electronic technology, motor drive technology, measurement and control circuit and microcontroller application technology, the principle diagram of balance control system is designed, and the circuit diagram of measurement and control system is drawn. In recent years, mobile robots have been widely used, almost penetrating into various industries, and the functions realized are becoming more and more complex.

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