The application of hall sensors ACS712 in the protection circuit of controller for humanoid robots

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***Abstract*— This paper presents a new method of direct current detection based on the hall sensor of ACS712, implemented protection in active way on the humanoid robot DC controller to overcome the shortcomings of fuse protection only in the passive way and long response time. The experiment showed that the method is validity.**

Keywords-humanoid robot Hall sensor ACS712 current detection

I. INTRODUCTION

We not only know the position of the robot joints, but also know that the value of the current of the servo motor for the whole H bridge circuit protection to meet the needs of humanoid robot control. Fuse protected only in the passive way and with long response time; put fuse and current-feedback protection together can ensure the absolute security of joint controller.

The traditional method to detect current is using bulky sampling resistor, which is not convenient for electrical isolation between the digital-analog. Using Hall sensors to detect, not only can reduce the system size, have better isolation and higher detect accuracy, but also will not affect the circuit being detected. The Hall sensor UGN-3501M which is widely used has a higher detection accuracy, but the linearity is not well, the temperature has a great influence to the detected accuracy as in [1]. The output voltage of the UGN-3501M only 1.4V when the current is 20A, more circuit for data processing was needed, which is not conducive to simplify the circuit.

The Hall sensor ACS712-20A has higher detection accuracy, better linearity ,less impact-ed by temperature, supplied by 5V DC; the output voltage is 4.5V when the current being detected is 20A,there need less circuit for data processing.

II. THE DESIGN OF SYSTEM HARDWARE

The current detection system which bases on Hall sensor and takes the single chip microcomputer C8051F060 for the core, can realize to detect the current of H-bridge circuits.

Current detection system includes a microcontroller data acquisition module, current detection module and display module alarm and the alarm display module. The system hardware block diagram are shown in Figure 1.

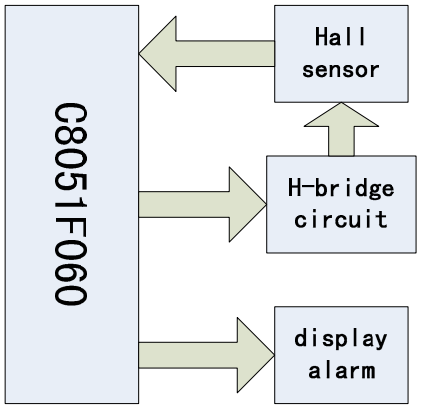

Figure 1. block diagram of the System hardware design.

A. The design of data acquisition module

Takes the single chip microcomputer C8051F060 for the core, data acquisition module using the microchip of C8051F060, as in [2], C8051F060 is a 25 MIPS Mixed-Signal 8051 with 59 I/O Lines, 5 Timers, Watchdog Timer, PCA, SPI, CAN 2.0B, 2 Channel (16-bit) A/D, 8 Channel (10-bit) A/D, 2 Channel (12-bit) D/A, 3 Analog Comparators, On-Chip Temperature Sensor, 64K Byte In-System Programmable FLASH, 256 Bytes RAM, 4K Bytes XRAM..

As shown in Figure 2：the reference voltage of the AD counters is 3.3V，DA1 is a Regulator diode of 3.3V。Add a 0.1uF Non-polar and a 47uF polar capacitor to the Cathodes and Anodes of the reference voltage to filter the low frequency and high frequency noise.

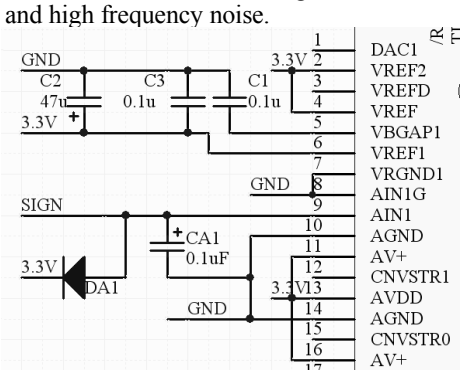

Figure 2. C8051F060 hardware connection diagram

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B. The design of current detection module

As in [3], The Allegro ACS712 consists of a precise, low-offset, linear Hall sensor circuit with a copper conduction path located near the surface of the die. Applied current flowing through this copper conduction path generates a magnetic field which is sensed by the integrated Hall IC and converted into a proportional voltage. Device accuracy is optimized through the close proximity of the magnetic signal to the Hall transducer. The internal resistance of this conductive path is 1.2 mΩ typical. The ACS712 is provided in a small, surface mount SOIC8 package. 5 µs output rise time in response to step input current, Total output error only 1.5% at 25°C, ACS712 typical circuit shown in Figure 3:

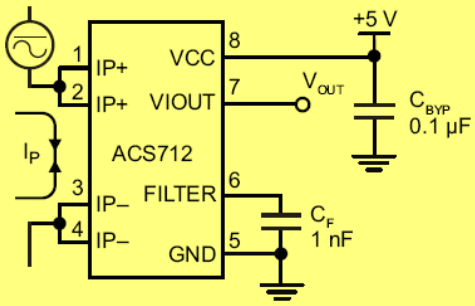

Figure 3. The Typical Application of ACS712.

C. The design of alarm circuit and display circuit

As shown in Figure 4, Humanoid robot joint controller circuit is formed by the sound and light alarm circuit. When the current less than 90% of the specified value, the servo motor run normally, When the current less than the, specified value, the servo motor run normally and turn on the yellow light, When the current more than the specified value, the motor stop servo and turn on the red light and to the buzzer beeps.

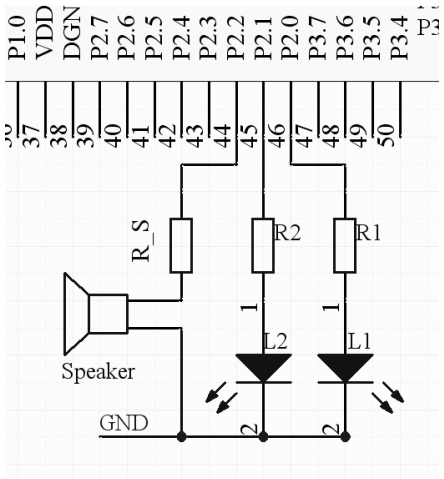

Figure 4. The circuit design of the alarm and display.

III. SYSTEM SOFTWARE DESIGN

The software design with modular structure was based on C, including the main program, Initialization Subroutine, Interrupt subroutine, Analog-to-digital converter subroutine and CAN Communication subroutine.

A. The main program design

The main program's main function is to complete the system initialization， receive joint position and velocity data in the interrupt way and receive the data of the current， When the current is more than the specified value, the motor stop servo; the control instructions are given after operation if the current if not greater than the specified value. The flow chart shown in Figure 5.

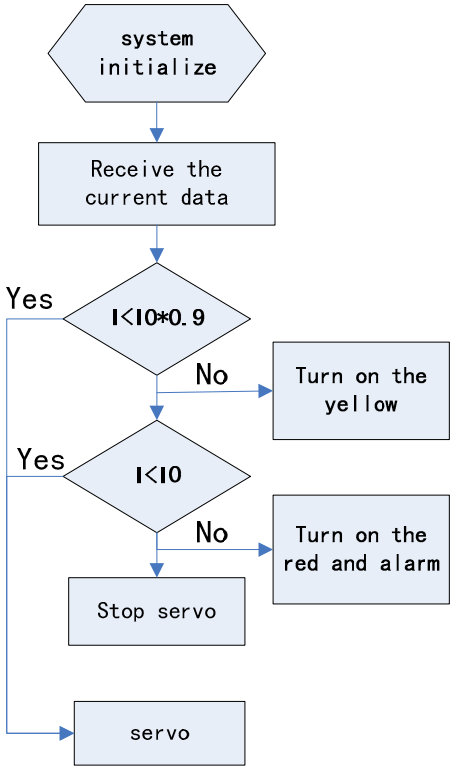

Figure 5. Main Programs Flow-Chart.

Some of the main program：

```
……
sbit  led_red  = P2^0;    // Definition of red light
sbit  led_yellew = P2^1;  // Definition of yellew light
sbit  led_speaker = P2^2;  // Definition buzzer
Main()
{ ……
  led_yellew=0; //turn on the yellow light
  led_red=0;    // initialize the red light
  led_speaker=0; // initialize the buzzer
```

```
if(ad1_result<0xa0){motor_run();}      /*When the current less than 90% of the specified value, the servo motor run normally*/
else if (ad1_result<0xc0)
{led_yellew=1;motor_run();}/*When the current less than the specified value, the servo motor run normally and turn on the yellow light*/
else    {led_red=1;led_speak=1;motor_stop();}/*When the current more than the specified value, the motor stop servo and turn on the red light*/
……
}
```

B. *Subroutine design*

After the system started, we not only initialize the MCU to make it work properly， but also initialize the various function module, Including initialization AD, initialize CAN controller, initialize interrupt to achieve various functions, These features include：

1) Acquisition Hall sensor signal , converted though the A / D converter and saved in the FLASH memory;

2) Read the data from the FLASH memory and processed through the filter, the instructions whether to stop the servo are given;

3) Read the data from the FLASH memory and give control instructions after operated ;

4) Erase FLASH memory.

IV. DATA ACQUISITION AND PROCESSING

The output voltage versus sensed current as shown in Figure6:

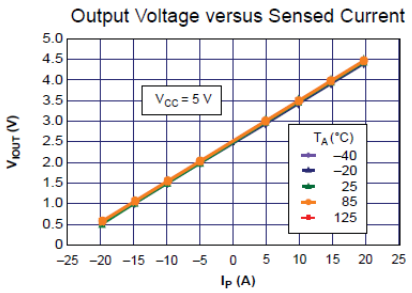

Figure 6. Output Voltages versus Sensed Current.

As the MCU AD range is 0-3.3V, while the ACS712 output voltage is 0.5V-4.5V, amplified by the amplifier (amplification factor is 0.73), the transformation of its range to the range of the MCU AD.

V. CONCLUSION

This paper proposes a method of Current Feedback to protect the H bridge circuit of the robot joints in active way, which combined with blown fuse to make the control circuit to ensure foolproof.

REFERENCES

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