Design of Teaching Platform for ABS Wheel Speed Sensor

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Abstract: In order to ensure driving safety, ABS brake systems are currently installed on cars. When the ABS is working, it needs to detect the wheel speed signal through the wheel speed sensor to realize continuous braking and relaxation to prevent the wheels from locking up. In daily teaching, it is difficult for students to observe the working process of the wheel speed sensor, and then understand the working condition of ABS in the braking process. So according to the working principle of electromagnetic induction wheel speed sensor, a simple experimental bench was designed and manufactured. This bench can clearly display the changes of the voltage generated by the sensors at different speeds during the rotation of the wheel, and then simulate the changes in the signal when the ABS is working.

1. Introduction
The normal operation of ABS requires a wheel speed sensor to transmit signals, and the wheel speed sensor of a car is installed in an extremely concealed position on the wheel. Therefore, it is difficult to observe the status when the ABS is receiving signals. Many schools do not have the experimental tools which can directly observe the continuous changes in the output voltage of the wheel speed sensor in daily teaching process. Students can only observe whether the sensor is working by measuring the voltage value of the wheel speed sensor with a multimeter. The data is relatively fixed, but this experimental bench can display the different AC voltages at different speeds very well, and realize the mutual comparison among multiple sets of data. It will make it easier for students to understand and master the working conditions and basic principles of ABS, and at the same time can measure the values accurately with a multimeter. Therefore, it is more accurate and more reliable.

The electromagnetic wheel speed sensor is mainly composed of a sensor head and a ring gear. The structure is simple at low cost, and its performance is relatively stable, reliable, and hardly affected by environmental factors such as temperature and dust. The electromagnetic wheel speed sensor is applied to this design.[1]

2. The installing structure design of wheel speed sensor
The operation of the automobile wheel speed sensor cannot be seen directly by eyes. This design is based on the working principle of the automobile ABS wheel speed sensor. The signal plate of the wheel speed sensor rotates by the signal plate which is driven by power. It can realize the voltage change by controlling the rotation speed. At the same time, the real-time speed of the signal plate can be observed, so as to directly observe the working condition of the wheel speed sensor. Figure 1 shows the key components of the entire design.
The wheel speed sensor of a car is usually installed on the wheel axle. A disc similar to the wheel is designed to replace the longer axle, and an iron signal disc similar to the ring gear is installed on it to make sure the wheel speed sensor can receive the signal.\textsuperscript{[2]}

This design uses the traditional front disc type and rear drum type brake system structures. The disc brake and drum brake structure are quite different from each other as well as braking method. Therefore, the ring gear of the wheel speed sensor is also different (the disc brake is big and narrow, and the drum brake is small and wide). Signal plates with two different braking systems are fixed on the same shaft, which can observe the work of speed sensor with two braking systems.

3. Wheel power scheme design

The wheel rotation is driven by a DC motor. We hope that the control of the motor is accurate. Different speeds can be set, and the speed can be measured and displayed at the same time. There are many such schemes. Combining all our equipment and selecting an idle DC servo motor, we build up a set of motor speed control system.

A servo system which is composed of a single STC12C5A32AD single-chip microcomputer, a PWM integrated chip LM629, a power driver LMD18200 and a servo motor with a photoelectric encoder is used in the wheel drive control system. System demands are met with high standards and ultra requirements.

The task of the single-chip microcomputer STC12C5A32AD in this system is to deliver PID data and motion data to the PWM integrated chip LM629. LM629 generates a speed map based on the relevant data that received, performs position tracking, PID control and generates PWM signals. LM629 transmits the PWM control signal to the power drive chip LMD18200 to drive the operation of the motor. The signal transmission between LM629 and LMD18200 needs to be isolated by a photocoupler, otherwise the start and stop of the motor will interfere with the chip LM629.\textsuperscript{[3]}

The feedback of the motor running data is detected by the photoelectric encoder. The photoelectric encoder directly transmits the detected signal to it via the A, B, and C input terminals in the LM629, so as to form a feedback link. The frequency of the feedback signal is quadrupled, which greatly improves its resolution. The hardware circuit design of the system is relatively simple. It only needs to interface the single-chip microcomputer, LM629, LMD18200 and photoelectric encoder, and only needs some simple peripheral circuits. The P0 port of the single-chip microcomputer is connected with the data ports D0~D7 of the LM629, which is used to transmit data and instructions from the single-chip microcomputer to the LM629. At the same time, the LM629 can also transmit the relevant feedback information of the motor to the single-chip microcomputer. The chip selection signal interface CS of LM629 is connected with pin P2.0 of the one-chip computer which is used for selecting the address line of LM629. The command/data selection port PS of LM629 is connected to pin P2.1 of the microcontroller as another address line. When PS output is low, the microcontroller can write instructions to LM629 or read status from LM629. When PS outputs level is high, the single-chip microcomputer writes or reads data through the data port. Among them, LM629 is
connected with a four-pin crystal oscillator to provide a clock signal, which can improve the response speed of the system

4. The design of other components

4.1. Power circuit design
In the hardware circuit design of the control system, the design of the power supply is indispensable. The design of the power supply is a systematic work which requires comprehensive consideration of power consumption, power distribution, and power management monitoring. The motor control unit circuit in this control system has relatively high requirements for the 5V power supply. The chip 7805 is used to complete the conversion from 12V to 5V as the power supply for the 5V unit of the single-chip microcomputer.

The peripheral circuit required by the stabilized power supply composed of chip 7805 is simple, and there are protection circuits for overheating, overcurrent and regulator tube inside the chip, which are packaged in TO-220 or TO-202. The actual use is convenient and reliable. The 7805 has three terminals including input, output and common. The circuit schematic diagram of the conversion from 12V power supply to 5V power supply completed by the 7805 chip is shown in the figure. Special attention must be paid to the fact that according to the operating principle of 7805, 7805 generates heat during the voltage conversion process, thus a heat sink must be added to 7805. At the same time, it is better to install a filter capacitor at the output of 7805, with a capacity of 100UF/16V. [4]

![Figure 2 5V power supply regulator circuit](image)

4.2. Safety device design
In addition, in order to ensure the safety of teaching, prevent some students from accidentally touching the rotating parts with their fingers and causing personal injury when the wheels are rotating at a high speed, safety measures are set. Safety fence is installed on one side, and on the other side a photoelectric sensor is installed. When an object approaches, the single chip microcomputer receives the signal through the photoelectric sensor, and then the motor will be stopped.

The main function of the photoelectric sensor is to detect the position. It is the key element for photoelectric conversion in various photoelectric detection systems. It is a device that converts external information into electrical signals. The photoelectric sensor firstly converts the measured signal changes into the light signal changes, and then the photoelectric element converts the light signal into an electrical signal. In this way, non-electricity can be converted into electricity. The voltage of the photoelectric sensor is not 5V, and the operating voltage of the single-chip microcomputer is 5V, so the signal of the peripheral sensor can not be directly connected to the corresponding pin of the single-chip microcomputer. Some hardware circuits or components must be used to convert the 12V voltage into a 5V voltage, and then connected to the corresponding pin of the microcontroller.
In the actual electronic circuit system, there are inevitably various interference signals. If the circuit's anti-interference ability is poor, the accuracy of measurement and control will decrease. Common signal isolation methods include photoelectric coupling and transformer isolation. The system design adopts photoelectric coupling for isolation to eliminate the interference of analog signals on digital signals. An optocoupler is a device that transmits electrical signals through light. It encapsulates the light emitter and the light receiver in a tube case. When an electric signal is applied to the input terminal, the light emitter emits light, and after the light receiver receives it, it generates a photocurrent, which flows out from the output terminal, thus realizing the "electricity-optical-electricity" conversion.\cite{5}

5. Standard Operation

5.1. Specific operation

Turn on the power, turn on the switch, turn the speed control knob until the motor can drive the shaft to rotate and until the reading is displayed on the voltmeter (see Figure 3-1, Figure 3-2). At this moment, the speed displayed by the tachometer is about 250 rad/s, the first set of data (voltage value) is recorded; continue to turn the knob until the speed reaches about 500 revolutions and the second set of data is recorded; and voltage value at 750, 1000, 1250, 1500, 1750, 2000, 2250, 2500 revolutions respectively are recorded (The allowable error is 50rad/s). After experiments, the maximum speed of this design is 2500rad/s.

5.2. Experimental data

The experimental data measured by the bench are shown in Table 1.
Table 1 Experimental data record table

| Speed (rad/s) | Reading of voltmeter 1 (V) | Reading of voltmeter 2 (V) |
|--------------|-----------------------------|-----------------------------|
| 250          | 0.1                         | 0.05                        |
| 500          | 0.6                         | 0.4                         |
| 1000         | 0.9                         | 0.6                         |
| 1500         | 1.0                         | 0.8                         |
| 1750         | 1.0                         | 0.8                         |
| 2000         | 1.0                         | 0.9                         |
| 2250         | 1.1                         | 1.0                         |
| 2500         | 1.2                         | 1.0                         |

5.3. Data analysis

From the measured parameters, it can be seen that when the speed is too low, there will be very low and almost zero voltage signal to be received by the wheel speed sensor. It approves that the electromagnetic wheel speed sensor cannot work normally at low speeds, and thus the work of ABS will be affected. Wheel speed sensor can receive signals normally when the rotation speed to a certain level. Normally, the voltage will increase with the increase of the speed, but the voltage of two voltmeters does not change in the speed range of 1250 ~ 2000rad/s. Use a digital multimeter to measure and find that the voltage value is changing. After analysis, it is found that the accuracy of the voltmeter is too low to show the change in voltage.

However, when the rotation speed increases, the voltage has a slow increase, which shows that there is a range for the normal operation of the electromagnetic wheel speed sensor, and it is unreliable if it exceeds the range. According to the parameters, it can be found that there is a gap between the maximum voltage at the maximum speed and the standard voltage. The preliminary consideration is that it is related to the distance between the sensor and the signal plate. When the sensor is closer to the signal plate, the voltage instantly increases, and the gap is not handled ideally. However it can basically meet the initial design requirements.

6. Conclusion

Based on the results and discussions presented above, the conclusions are obtained as below:

(1) The ABS Wheel Speed Sensor Teaching Platform runs well, the mechanical structure design is reasonable, the electronic electricity is stable and reliable, which can satisfy the teaching demand well.

(2) According to the experimental results, the ABS wheel speed sensor teaching platform can directly and clearly reflect the performance of the ABS wheel speed sensor.

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