Design and Implementation of Electromagnetic Navigation Smart Car

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***Abstract*—This essay introduces the self-tracking intelligent vehicle system with KEA 128 microcontroller as the core control unit. It was launched in 2014 by NXP semiconductor. The rapid, accurate and stable identification of the track and normal operation of the environment is a necessary condition for the successful completion of the competition of the smart car, and it is also a necessary skill for the self-tracking smart car system. The output of PWM waves is controlled by the inductance placed in front of the smart car to change the intensity of the alternating magnetic field of the track, so as to control the speed of the motor, so that the speed and steering of the smart car can be accurately adjusted, and finally self-identify the track. The production of smart cars that can complete the entire race.**

***Index Terms*— Microcontroller; Smart car; Electromagnetic induction; Path recognition**

I. INTRODUCTION

The rapid development of the automotive industry, bold design, and rapid development of technology have begun to develop in the direction of smart cars. Many advanced technologies have been used in smart car systems, such as sensor technology and computer technology and so on. Based on the background of NXP intelligent car, this paper introduces the structure frame, mechanical design, hardware design, software design, and PID algorithm control of intelligent car to realize the sensitive control of track magnetic field.

II. HARDWARE CIRCUIT MODULE

A. Main control chip

The KEA128 microcontroller is a 32-bit ARM controller with rich internal resources and a set of powerful analog, communication, timing, and control peripherals. The KEA128 microcontroller has 80 I/O pins, many of which have reset functions. Its internal configuration FTM counter is responsible for selecting Clock Source, input frequency, etc. according to its counting cycle to output PWM[1].

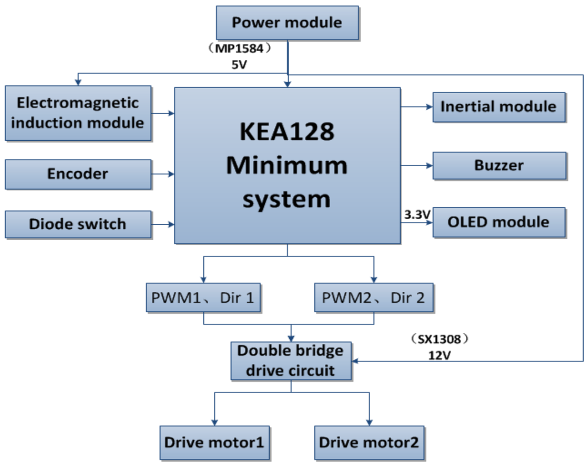

Figure 1. System Box

B. Power modules

The power supply module provides a suitable and stable power supply for the entire system, especially for the power supply of the single chip microcomputer. In this system design, the Main control chip, Electromagnetic induction module, Encoder, Inertial module, Dialing switch, and Buzzer all use 5V power supply; The OLED module uses 3.3 V power supply and the motor drive chip uses 12V power supply. The power supply voltage is about 7.2 V, so the power supply module is divided into a pressure-relief module and a pressure-raising module.

(1) Pressure relief module

This system design uses MP1584 chip to reduce the input voltage. MP1584 uses a SOIC8E package with an operating voltage of 4.5-28V, an operating frequency of 1.5 MHz, and an output current of 3A. Its schematic diagram is shown in Fig 2.

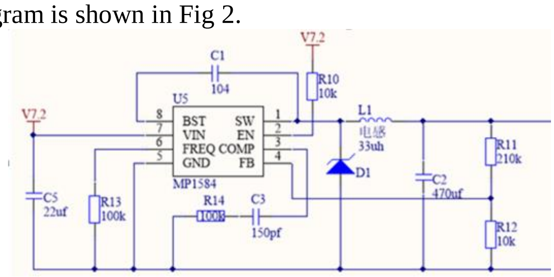

Figure 2. Principle diagram of the pressure-relief module

(2) Pressure lifting module

The step up circuit is also called a bootstrap circuit. The SX1308 is an ultra-small package with high efficiency and DC boost voltage stabilizing circuit. The input voltage is raised to 12V to power the motor drive chip IR2104. The schematic diagram is shown in Fig.3.

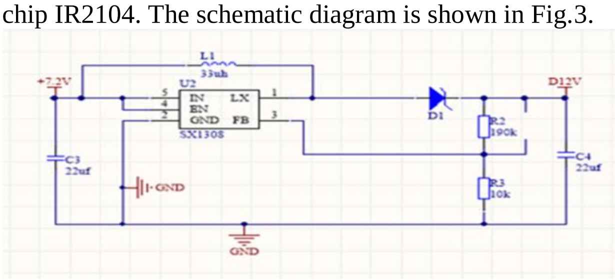

Figure 3. Principle diagram of the booster module.

C. Encoder module

An orthogonal encoder is used in the intelligent vehicle system to measure the real-time speed of the vehicle and return it to the main control chip, which is one of the input parameters of the control strategy. Orthogonal encoder consists of three main functional components of photoelectric code disk, transmitter and receiving device. The speed of over-receiving frequency is determined, and the over-phase difference is determined to be FWD or REV[2]. The system design uses two E6A2-CW 3C drive motors to drive two rounds respectively.

D. Electromagnetic induction module

At the center of the electromagnetic track there is a 100mA alternating current wire, which is the source of information for the navigation of smart cars. According to Maxwell's electromagnetic field theory, alternating electric fields produce alternating magnetic fields[3]. The intelligent car race uses a path navigation AC current frequency of 20 kHz. The induced magnetic field distribution is a series of concentric circles with the conductor as the axis, and the magnetic field strength on the circle is the same, as shown in Fig. 4.

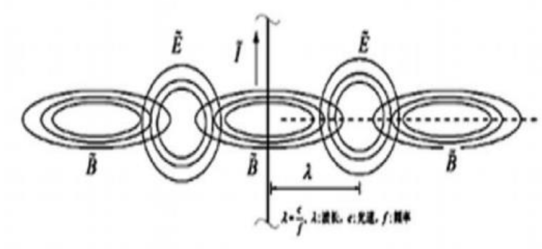

Figure 4. Electromagnetic field around the track

E. Motor Drive Module

The motor drive module is a Dual Full-Bridge composed of a selector 74HC157 and a drive chip IR2104. Through the 74HC157, it chooses to output two PWM signals and output different PWM signals to drive the DC motor to achieve speed regulation. Its schematic diagram is shown in Fig. 5.

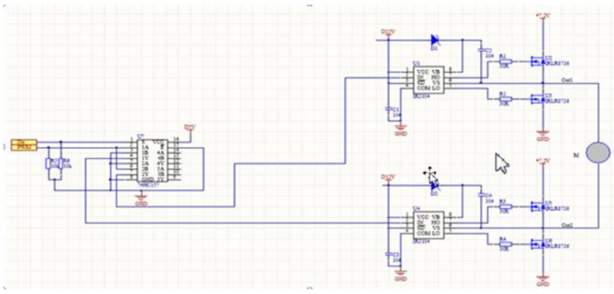

Figure 5. Principle diagram of the driver module

F. OLED module

The OLED module is a human-machine information interchange module that displays inductance parameters and monitors the state of the vehicle in real time, thus making judgments that have a great role in the debugging process of the car.

G. PWM

PWM is mainly used for the speed control of intelligent motor and the rotation angle control of steering gear. PWM is also called pulse modulator and is one of the common functions of embedded application systems. PWM produces a cycle of repeated alternating between high and low levels, called PWM wave signals, also known as pulse width modulation waves.

The pulse duty factor of square waves is 50 %. The pulse duty factor is the percentage of the time or period of the high level that accounts for the entire pulse period. Pulse width refers to the time when PWM is at a high level. PWM can also control the voltage of the input device, such as a DC motor that rotates when there is voltage input, and the motor's rotation speed is proportional to the size of the input voltage. Suppose the speed at which the motor rotates every minute is 50 times the input voltage, if the motor's speed reaches 240r/min, the input voltage is 4.8 V.

III. SOFTWARE CIRCUIT DESIGN

A. Path recognition

Good hardware design requires the same good software to maximize its function. According to the actual needs of electromagnetic vehicles, the software design mainly includes path recognition algorithm, direction control algorithm design and motor control programming. Path recognition is the soul of intelligent car, which is the key part of determining whether the car can successfully complete the track. A good path recognition module program can enable the car to run smoothly on the track and show good flexibility. The design uses an inductance sensor to detect the 20kHz alternating electromagnetic waves emitted by the enameled wire prelaid below the track. The software design mainly has the processing of the inductive sensor sampling value, and the obtained value is used to control the steering of the car. The entire path recognition module works as follows: after the system is powered, the road condition is detected. When the AD module is processed, the collected data is processed and calculated, the road trajectory is obtained, and the approximate curvature of the road is calculated. Combined with the speed value of real-time detection, the purpose of controlling steering and DC motor speed is to control direction and speed. Its system diagram is shown in Fig. 6.

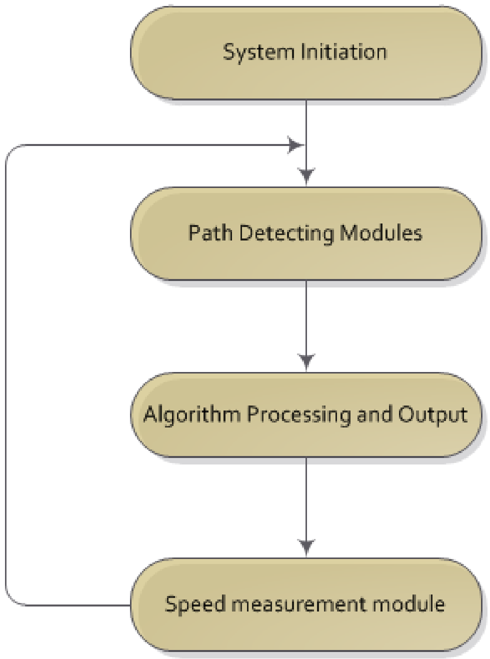

Figure 6. Control System Box

B. PID control

PID control strategy has simple structure, good stability, high reliability, and easy to implement. PID control mainly consists of three parts, proportion, integral, and differential.

The function of proportional adjustment(P): Reflects the deviation of the system in proportion, once the system goes deviation, The proportional adjustment immediately produces a regulatory effect to reduce the deviation.

The function of integral adjustment(I) is to make the system eliminate the steady state error and increase the no-difference degree. If there is an error, the integral adjustment is performed until there is no difference, the integral adjustment stops, and the integral adjustment output is a constant value. The product integral action is often combined with the other two adjustment laws to form a PI regulator or a PID regulator.

Differential Regulation(D): D-action is reflects the rate of change of the system deviation signal, is predictable, can foresee the trend of deviation change, and therefore can have control ahead of time. Differential reaction is the rate of change, and when the input does not change, the differential effect output is zero. D-action can not be used alone and needs to be combined with two other regulatory laws to form a PD or PID controller.

C. Speed control

```
if(gpio_get(H7))//key1 key2    1 stalls
  {
    SPEED_CONTROL_P=0.01;
    SPEED_CONTROL_I=0.00001;
    SPEED_CONTROL_D=0.000;
    car_speed_set=90;

    DIR_CONTROL_P=2.6;
    pre_circle_min_ad=130;
    goto_circle_min_ad=180;

    didi();
  }
  else      //2 stalls
  {
    SPEED_CONTROL_P=0.01;
    SPEED_CONTROL_I=0.00001;
    SPEED_CONTROL_D=0.00001;
    car_speed_set=105;

    DIR_CONTROL_P=2.9;
DIR_CONTROL_D=8.0; pre_circle_min_ad=130;
    goto_circle_min_ad=170;
    didi();
    didi();
  }
```

IV. CONCLUSION

This paper discusses the use of electromagnetic sensors to collect external road signals, through circuit transport amplification, single chip processing, PID closed-loop control, PWM wave stable output, double bridge circuit drive motor. This smart car has good stability and smooth driving. It can identify different road forms and the average speed can reach 2.1 m/s.

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