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Vehicle Detection System Based On Magnetoresistive Sensor

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Abstract. According to the vehicle after geomagnetic disturbances cause of this phenomenon, in-depth theoretical study of the anisotropic magnetoresistance AMR sensors, using triaxial anisotropic magnetoresistive sensor HMC5883L design a vehicle detection system. The system consists of a sensor module, wireless communication module. Sensor nodes through wireless communication module connected with the host computer, to achieve the detection of vehicle information.

Introduction

With the rapid development of intelligent transportation industry and the practical needs, vehicle information collection has a wide range of cover parking, streets and highways. At present, a sensor for detecting the vehicle include loop coil, video, microwave, and magnetoresistive sensors principally.

Vehicle detection system based on magnetoresistive sensor has a small size, high sensitivity, easy to install and so on, and it can address the high cost of conventional vehicle detection and vulnerability to environmental impacts and other shortcomings ,for the development of vehicle detection technology provides a new way of thinking and motivation.

AMR Sensor Detection Principle

That the Earth's magnetic field is either a uniform distribution of the magnetic field on the earth, its size and the direction is certain,the size is about 0.5 to 0.6 gauss, the direction is connected with longitude and latitude. Any object containing ferromagnetic material such as vehicles, will have an impact on the Earth's surface when moving or still on the distribution of the geomagnetic field[1].

AMR sensors are based on anisotropy magnetoresistance effect . Its based devices are Megumi Wheatstone bridge. Wheatstone bridge will output through changes in the magnetic field converted to the form of differential voltage. Resistor bridge from permalloy material, which function of the angle between the presence of the bias current and the resistance value between the magnetic field vector. Within a certain range, the resistance changes with the linear relationship between the magnetic field vector [2].

AMR sensors in three dimensions (x, y, z) of the individual sensors integrated in the same chip, the use of the three axes, respectively to detect the vehicle traveling direction and in a direction perpendicular to the surface component of the magnetic field vector parallel and perpendicular to, and will sensors and regulation, compensation circuit for Integration, measuring range from gigahertz to 8 gauss.

When a vehicle passes over the sensor with AMR, the magnetic field in this region will have a relatively large transient effects, changes in the external magnetic field will result in a change in the output value of the sensor;and when the vehicle leaves the target area, the magnetic field to restore the original state. So long as a magnetoresistive device placed on a vehicle parked by the region's vehicle information can be judged by the change of the geomagnetic field, through this sensor can detect road traffic, vehicle speed estimation.

Hardware Design In Vehicle Detection System WhichBased On Magnetoresistive Sensor

Vehicle detection system based on magnetoresistive sensor manufactured using TI's CC2530 chip as the wireless communication module and Honeywell production company AMR sensor as the sensor module. That select HMC5883L for information gathering sensors, combined with wireless sensor networks (Wireless Sensor Networks, WSN) vehicle information acquisition and control systems. Wireless sensor network hardware components which are mainly: PC machine, Coordinator (base station), routing equipment, terminal equipment, lights and so on.

The detection system is the use of magnetoresistive sensor nodes, namely road terminal equipment field information collected and transmitted to the routing nodes between multiple routing nodes self-organize into a wireless mesh network, the data is transmitted to the coordinator node, go to the PC filter noise, and then make a judgment after extracting feature information related algorithms [3]. Vehicle detection system structure shown in Fig.1.

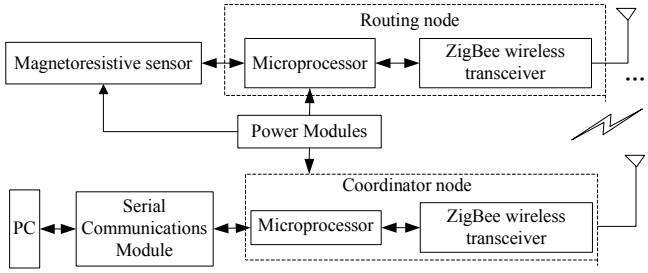

Fig.1 Vehicle Detection System Block Diagram

(1) Microprocessor Modules

The microprocessor module is responsible for controlling the entire operation of the sensor node, which is the core of the wireless sensor node under its control, and can realize the data collected by other nodes in the node data sent for storage and processing.

In this paper adopt ZigBee wireless communication technology, which is developed in the beginning of 2001,based on IEEE802.15.4 ,a standard communications technology. Here use the CC2530 to achieve ZigBee technology, which integrates 8051CPU, memory, voltage regulator, RF transmit/receive end, with a radio frequency functions, and therefore does not need to do additional radio chip RF transceiver simplifies the RF circuit design. And a variety of operating modes ensure low power consumption of the chip, and has a very high receiver sensitivity and robustness.

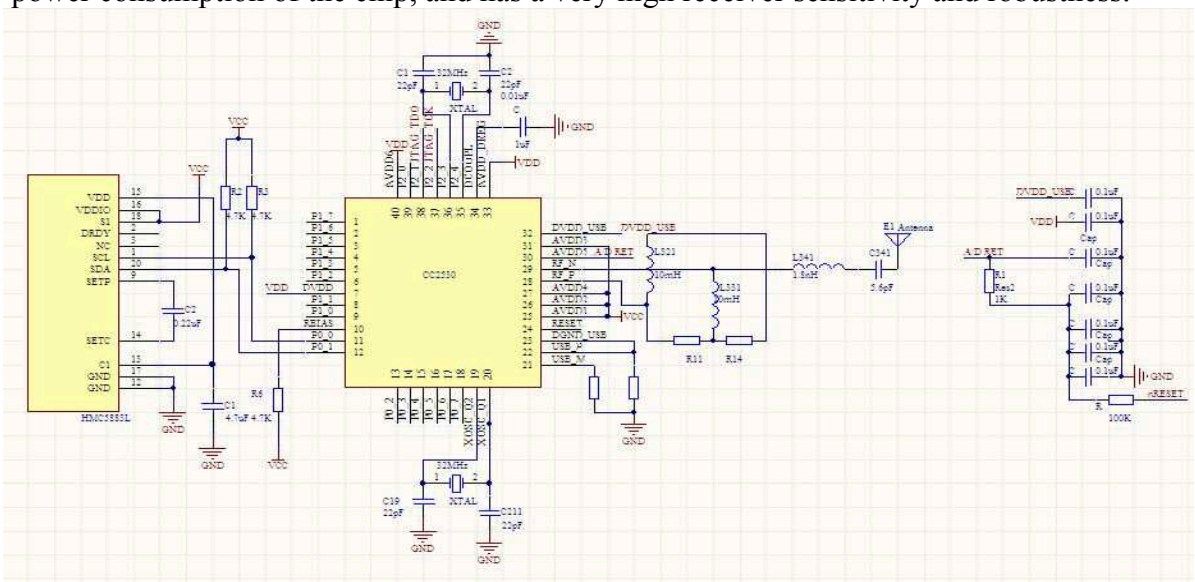

Fig.2 Sensor Node Circuit

(2) The Sensor Node Module

HMC5883L three-axis magnetoresistive sensor selection, it can achieve a resolution of 5mGauss ± 8 Gauss magnetic field to meet the needs of the vehicle detection. In addition, the internal sensor

with a self-test function (which can take advantage of the internal field test to detect its output is normal), the driver circuit and an I^2C interface for communication via the I^2C interface and CC2530. Serial data and the serial clock pins are connected CC2530 chip P1_0 and P1_1. HMC5883L and CC2530 wiring diagram shown in Fig.2.

(3) Power Modules

Most of the hardware of the system voltage stability at 3.3V, only a handful of chips have special requirements for voltage.In this paper, power chip for TPS 780300250DRVR, it is a type of low-dro

pout voltage regulator chip, the chip allows the maximum input voltage of DC 5.5V, the output voltage is constant 2.5V/3V, meet the electrical supply needs. TPS 780300250DRVR reliable, interference is strong, simple to use.

(4) Serial Communications Module

Serial communication module is an important part of the magnetoresistive sensor node design ,to achieve PC and communication interfaces for data exchange, transfer, and programme the wireless communication module into the hardware systems, achieve between the sensor and the sensor nodes each mutual communication between the node and the receiving node aggregation[4], issue instructions through the PC, data processing, changing the operating mode of the sensor nodes. Therefore, we must design serial communication module on the coordinator.

3.Vehicle Detection System Algorithm Based On Magnetoresistive Sensor

The most core problems is algorithmic in AMR sensor-based vehicle detection system, the principle is the use of magnetic disturbances to the identification of the vehicle and extract the signal characteristics of the vehicle when the vehicle passes the true reaction, while excluding the impact of the noise signal and the background signal detection accuracy .

Due to the complex background signal, magnetoresistive sensor to the signal often with obvious glitches phenomenon, which will give accurate detection of some impact, so the design detection algorithm, people need to collect to the original signal filtering, filtering methods commonly used median filter and mean filter.

Mean Filtering refers to the data collected sum, its average. Continuous sampling n times, averaging these n data for smoothing. Assuming an average value of n sampling geomagnetic signal is $g(k)$, real-time sampling value of $m(k)$. As shown in Eq.1.

$$g(k)=\begin{cases}\dfrac{m(k)+m(k-1)+\cdots+m(1)}{k}, k<n\\ \dfrac{m(k)+m(k-1)+\cdots+m(k-n-1)}{n}, k\geq n\end{cases} \tag{1}$$

Car environment there will be no magnetic background signal is called the baseline value. AMR sensor output is complicated by external ambient temperature, if the outside temperature changes occur in a short period of time, then the baseline will happen obvious dislocation, which produce a step, to become unstable. That baseline drift problem exists. Therefore, it is necessary to carry out temperature compensation of the baseline. Its principle is processed by the sensor itself self-test function to achieve, at the time did not enter the detection state, allowing the sensor to be adjusted from time to time, enter the self-test state. The current self-test values $S_i(r)$, the compensation factor $u_i(k)$ is obtained by the following Eq.2.

$$u_i(k)=\frac{S_i(r)}{S_i(n)}, i\in(x,y,z) \tag{2}$$

By sampling the signal with a threshold comparison, when the difference exceeds a predetermined threshold value, by extracting a peak value of the signal correlation processing characteristics, to make a judgment. Threshold system is several field experiments set a fixed value.

Ideally, the sample value and the comparison result of the threshold value in the absence of the car are zero, the vehicle remains after the period of 1; and the actual vehicle itself has many fluctuations in the magnetic signals, and the presence of interference uncertainties, the result of the threshold value comparison will cause between 1 and 0 produce short-term bounce, can easily lead to vehicle arrival or departure of miscarriage of justice. To this end the introduction of the state

machine, as a result of the threshold comparison state machine for processing the input, by the addition of a transient state to reduce the input short beating, while allowing the vehicle is determined based on the state transition time of arrival and departure.

Vehicle Detection System Test Based On Magnetoresistive Sensor

Experimental tests are carried out on a single lane road.The information collection nodes placed in the middle of the lane for a vehicle to monitor the lane on the X-axis magnetoresistive sensor along the direction of travel of the vehicle, Z axis is perpendicular to the direction of travel of the vehicle upright. Vehicle information gathering nodes transmit the collected routing node to node roadside coordinator, the coordinator node is directly connected via RS232 interface and PC. In order to verify the accuracy and reliability of the algorithm, for passing vehicles for a number of measurements and statistics, the results shown in Fig.3.

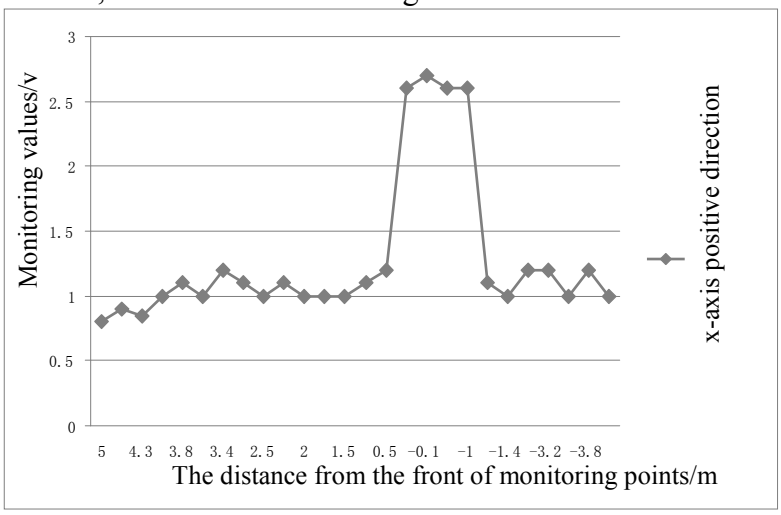

Fig.3 The Measured Waveform Detection Node A

It was found that when the vehicle by the detection node from the top, there is a significant change in the detection value can be accurately discriminated whether the vehicle passes the lane.

Conclude

Vehicle detection system based on the use of three-axis magnetoresistive sensor is a magnetoresistive sensor for detecting the vehicle when the vehicle passes through the sensor, the vehicle ground disturbance around the uniform distribution of the magnetic field sensors, magnetic field sensors can be accurately changed to obtain the data of the vehicle is determined by the situation. The design is independent of temperature and harsh weather, small size, easy maintenance, etc., for detecting a vehicle having a good effect, while a simple algorithm, run fast. Can be applied to the field of intelligent transportation vehicle detection.

References

[1] Bo yang,Wenbin Ni. Detection and classification models based on anisotropic magnetoresistive sensor vehicles[J]. Instrumentation Technology, 2013,34(3):537-544.

[2] Michael J C,Bratland T,Smith C H,et al.A new perspective on magnetic field sensing[J].Sensors Magazine, 1998(12):34-36.

[3] He B,Jiang L G. A scheme design and implementation of parking detector in intelligent[J].Science Technology and Engineering，2013,13 (23) : 6774—6780.

[4] Xiaosen zhang. Research and Implementation of a magnetoresistive sensor vehicle detection algorithm [D] . Beijing :Based Beijing Jiaotong University,2012.