Design of Sharing Bicycle Smart Lock System Based on Bluetooth and GPRS Communications

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ABSTRACT

In order to meet the demand of sharing market especially the bike-sharing industry, a smart lock system based on Bluetooth low power and GPRS communication is designed. The connection with the user’s client via Bluetooth and the control of the whole system is realized by using CC2541. GPRS communication with the server is realized by SIM800C and GPS positioning module is added. The unlocking methods of scanning two-dimensional code and entering the password are designed in terms of use to protect the normal use of the bike. The charging circuit design is completed to ensure the continuous power supply system using solar charging.

INTRODUCTION

With the maturing of the bike-sharing market, the problems arising from the use and operation of management are gradually exposed. The password of traditional mechanical lock is the only one which is easy to crack and has the risk of being changed. In contrast, smart electronic locks can change passwords in real time. However, the existing bicycle smart locks on the market mainly rely on GPRS communication and the reliability is limited.

This design uses two communication methods. Bluetooth low power has low power consumption, fast connection, low delay and other advantages and has been supported by many operating systems which make it to be an important technical support for intelligent connection. GPRS (General Packet Radio Service) can provide higher data transmission rate than the GSM network. This design uses IAR for 8051 as development environment to realize the application of low-power Bluetooth, while using GPRS mode to communicate with the server. The user can unlock the lock in two ways, namely, scanning two-dimensional code and key input password, to ensure the reliability of use. Moreover, the GPS module is contained to obtain the specific location of bikes which provides effective data for user usage and administrator operations. The smart lock electronic system in this design can be applied to other sharing industries.
OVERALL DESIGN SCHEME

The whole system structure is shown in Fig.1. The power supply part realizes the charging of a solar panel to a battery ensuring the power supply of the whole system. The control and communication section are responsible for the control of the whole system, the communication of server and user and the acquisition of the position data. The part of function realization includes the motor and limit switch which realizes the switch function of lock, the vibration detection module, the keystroke keyboard for inputting the password and the buzzer that provides audible cues. This paper mainly discusses the design of the control and data communication section and the power supply section.

DESIGN OF HARDWARE

Bluetooth master module

The control chip adopts CC2541, which is a 2.4GHz low-power Bluetooth master chip manufactured by TI Company in accordance with the Bluetooth 4.0 Protocol. It has a high-performance, low-power 8051 microcontroller core with code preprocessing function. It provides sufficient resources to use the system design. As shown in Fig.2.

Figure 1. Hardware structure diagram of system.

Figure 2. Schematic of Bluetooth master chip.
GPS/GPRS module

This design uses SIMCOM module to achieve wireless mobile communication function. This module supports 4-band GSM/GPRS. This design provides a 3V supply voltage for SIM card interface, uses the IOT card, connects the GSM antenna and sends AT commands and data through the serial port to achieve the basic functions of opening GPRS, turning off GPRS, querying whether there is a SIM card or not, querying GPRS connection status, querying SIM card number, querying if the network is available, querying signal, sending and receiving short message.

The GPS module uses ublox7020 module of. The high sensitivity GPS antenna of 25×25×4mm is used. This module adopts TTL level output, UART serial communication and NMEA0183 communication protocol with the data transfer rate is 9600bps. The instructions that main control board passes to GPS module mainly achieve the basic functions of opening GPS, turning off GPS, querying signals, reading location information in single time or in a specified length of time.

Power supply and charging circuit

The power supply section of this design adopts 3.7V/6000mA lithium batteries. And the solar panel provides 5V voltage to the charging part after being stabilized. The charging process of lithium battery is divided into three stages: trickle charging, constant-current charging and constant-voltage charging. In order to avoid the influence on life and performance of lithium battery produced by overcharge, this design adopts linear charging management chip MCP73831 to control current and voltage of charging and to carry out the monitoring and protection of overcharging. As shown in Fig.3(b), value of resistance R6 is set to 1.24kΩ to control the charging current at 800mA. The charged lithium battery provides 3.3V voltage for other modules after reducing the voltage through the CMOS voltage regulator.

The chip may be damaged due to voltage fluctuation because of the change of illumination intensity. In this paper, an over-voltage protection circuit is designed to monitor the voltage supplied by the regulator circuit to avoid this problem. At the same time, an over-discharge protection circuit for monitoring the voltage of the lithium battery is designed to avoid the excessive discharge and the capacity reduction of the lithium battery. Both of these two circuits are composed of a relay, a voltage comparator and peripheral circuits. They connect between Protect_OV1 and Protect_OV2 and Protect_OD1 and Protect_OD2 respectively and monitor the voltage at the Protect_OV1 and VBAT terminals. The circuit will be disconnected when the input voltage is over 6V or the battery voltage is below 3.5V.

(a) The structure diagram of power supply section
The bicycle smart lock system is in low power state and sends a broadcast at a fixed interval. User’s mobile phone obtains the MAC address through the APP scanning the QR code and tries a Bluetooth connection to the corresponding system. Once the connection is successful, the phone sends the unlocking command containing the MAC address and the lock is opened after correct verification of the MAC address. Then the system will open GPS module to get address information and start the timer. It will open the GPS again and stop the timer after user locking the lock. The system stores all data generated in the course of using process in the lock, establishes Bluetooth connection with the phone and transmits those data to the phone at the end of using. The data will be uploaded to the server by the phone. During this process, the system opens the GPRS module and uploads the data if the Bluetooth connection fails. The system will get into low-power state after the completion of its work. The specific process is shown in Fig.4(a).

If the Bluetooth does not open or the connection fails at the start of using, APP will apply for the real-time password to the server and show it with the start of charging. Then user can enter the password to open the lock. The system will open GPRS module to upload data to the server after the user has finished using the bike. The specific process is shown in Fig.4(b).

When the starting of GPS or GPRS module is aborted or overtime during
The whole process, the system will attempt to restart it after a fixed time interval and give up after 3 failed attempts. In addition, the data saved in the system will be checked at a certain frequency after using to confirm the sending of data is completed.

**COMMUNICATION TEST**

This paper uses the hardware serial port communication protocol analysis software to monitor the serial port. The communication data on the serial port line is obtained by using to serial ports. One receives TX data on the serial port and the other receives RX data. The test mainly monitors the data of GPRS module uploaded to the main chip through the serial port and judges whether the GPRS module’s work and its communication with main chip are normal or not. The data obtained is shown in Fig.5.
CONCLUSION

The basic functions are achieved in accordance with the project designed in this paper. This design emphasizes the features of low power, fast and short distance of Bluetooth and takes it as the fundamental mode of communication with the GPRS communication with the server is added. Therefore the users can unlock the system by scanning the two-dimensional code or inputting password by keyboard and the success rate of unlocking is guaranteed. Positioning function of GPS was affected by environmental factors in the later experiments and it was easy to failure in indoor.

REFERENCES