Intelligent Lock Design Based on BLE

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Abstract. This design is of intelligent electric power security lock and its key based on the new generation SoC TLSR8253, which supports Bluetooth LE 5.0 technical standard. The system is mainly composed of intelligent electronic key, intelligent passive lock, Bluetooth handset and management center. Intelligent passive locks can be opened with powering by electronic keys, and can retrospectively manage keys and users, bind personnel identity, control the power of opening and closing, improving site safety and enhancing the manageability of assets.

Introduction

At present, the safety protection of indoor equipment such as power stations, transformer substations, distribution stations, the ring cabinets, box transformers, branch boxes, underground cable covers and other outdoor equipment in the distribution network of China's power industry, most of them still use mechanical locks (padlocks, handle locks, cabinet locks). Its reliability and safety are not high. Safety incidents such as illegal invasion, theft and disoperation of power equipment and facilities occur from time to time, which brings serious hidden dangers to the safe operation of power.[1-3]

In addition, it is inconvenient to open the meter box by carrying a large number of keys when collecting, maintaining, changing and viewing meters. The current lock control cannot track and record the switch information of the ammeter box. When the ammeter box is opened abnormally by illegal persons, it can't alarm in time and is very vulnerable to electricity theft.

In order to meet the intelligent requirements of power safety operation and management in the new situation, a smart lock control system for electric power safety based on BLE 5.0 technology is designed. Through the advanced technology of Internet of things, Internet plus information integration, the dynamic security control of all kinds of power grid equipment and facilities can be realized, and the current matching / changing power grid can be well solved. The problems of safe operation and management are helpful to the development of power grid.

System Design

The intelligent lock control system for power security designed in this paper mainly includes four parts: cloud server, Bluetooth handset, intelligent key and intelligent passive lock. The system structure chart is shown in Figure 1. This paper will focus on the embedded software and hardware design of keys and locks, and Bluetooth handset is a common handset of national network system with Bluetooth communication in the market. Server development is not the focus of this journal and will not be discussed in detail.

The smart key communicates with the handset first, then it downloads the password replacement information of the smart lock acquired from the cloud server in the handset and updates its own password. After inserting the key, it supplies power to the intelligent lock, and communicates with the intelligent lock to complete the lock-related information such as unlocking, unlocking record reading, password replacement, etc., and communicates with the handset to upload the unlocking information of the record.

Cloud Server

Cloud server is deployed in the cloud, running system management software, which can manage intelligent locks, electronic keys, user information, etc. It can centralize the management of unlocking authorization, and can control the user's unlocking authority, retrospective management,
and improve the safety of the site, and strengthen the manageability of assets and the responsibility of users. It is suitable for equipment safety management and personnel field management in the working process of inspection, maintenance and construction in various industries.

**Bluetooth Handset**

Bluetooth handset can communicate with server or key through Bluetooth. It can update key privilege information, etc.

**Intelligent Key**

Intelligent keys are divided into two kinds, one is common keys, which are used by unlocking personnel on the spot. It has the functions of identifying locker-unlocking personnel, recording information and unlocking, and the other is management keys, which have the function of changing the key of intelligent locks.

![Figure 1. Structural Diagram of Intelligent Lock Control System.](image)

**Intelligent Passive Lock**

It is use for two-way security verification of the key, and confirming the legal identity of the key, and unlocking, and recording the unlocking information.

**Hardware Circuit Design**

The following is the implementation of some specific circuits of intelligent key and intelligent passive lock core.

**Intelligent Key**

The hardware circuit of intelligent key is composed of BLE5.0 SoC control circuit, lithium battery and its charging circuit, security encryption module, etc. It mainly receives the authentication and control information of the handset through Bluetooth and drives the intelligent passive electronic lock through contact. At the same time, the state information and switch record of the intelligent passive electronic lock are transmitted to the handset through Bluetooth.

![Figure 2. Hardware Structure of Intelligent Key.](image)
BLE5.0 SoC Control Circuit

TLSR8253 is a new generation of BLE SoC which supports BLE5.0 and Mesh networking. It can provide high integration and ultra-low power applications. It integrates 32 bit MCUs, BLE RF transceivers, 48KB SRAM, 512KB internal Flash, 14-bit ADC with PGA, 6-way PWM and rich GPIO interfaces on a single chip, including supporting for almost all peripherals needed for BLE applications development[5].

Lithium Battery and Its Charging Circuit

In the smart key, the main power source comes from lithium batteries, which can be charged through USB interface. USB charging circuit uses AP5054C as the main chip, while VA7062MER chip is used to build charging protection circuit.

Secure Encryption Module

The security encryption module uses ESAM (Embedded Secure Access Module) chip to complete data encryption and decryption, two-way identity authentication, access control, temporary key export functions. It communicates with BLE SoC via SPI.

B Intelligent Lock Core

The hardware circuit of the intelligent lock core realizes the single-line serial communication with the intelligent key and the electronic driving function of the mechanical locking structure. The hardware structure diagram is shown in Figure 3.

![Figure 3. Hardware System Diagram of Intelligent Lock Core.](image)

Main Control Circuit

The MCU GD32E230F4V6 based on Cortex M0 core is used as the main control chip of the lock core. Its LGA20 small size package can break through the restriction of volume approaching in the lock core. The drive of DC motor is realized by simple power amplification through N-channel MOSFET, as shown in Fig. 4.

![Figure 4. Circuit diagram of main control unit of intelligent lock core.](image)
Power Supply Circuit

The power supply of the lock core is built with the LDO chip SGM2300 encapsulated in SOT23, which further reduces the size of the circuit board.

Embedded Software Design

The design of embedded software mainly includes the software design of TLR8253 and GD32E230F4V6. The software flow chart is shown in Figure 6.

A BLE Module Software Design

The Tailing BLE software architecture consists of the APP application layer and the BLE Stack protocol stack, where the stack_config.h file is used to configure some configuration parameters in the BLE protocol stack. BLE protocol can be divided into two parts: Bluetooth Application and Bluetooth Core, and Bluetooth Core includes BLE Controller and BLE Host. Controller is responsible for defining the specifications of partial hardware such as RF, Baseband, and abstracting the logical links for communication on this basis; Host is responsible for more friendly encapsulation on the basis of logical links, which can shield the details of Bluetooth technology and make Bluetooth Application more convenient to use.

This paper introduces the hardware and software implementation of BLE-based intelligent lock control system for electric power safety. The intelligent E-lock is communicated and powered by keys without power supply and any batteries, and the lock core adopts the same size as the original mechanical lock, which can be directly replaced, and the construction is convenient. The management center can grant temporary authorization remotely, realize the distributed management of keys, retrospectively manage keys and users, bind the identity of personnel, and control the opening and closing rights. The system has been applied in several provincial companies, and the system runs steadily with good market feedback.
Figure 6. (a) Main Program Flow Chart of Key-side BLE SoC; (b) Main Program Flow Chart of Lock-side MCU.

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