Applied Mechanics and Materials *Online: 2012-05-14*
ISSN: 1662-7482, Vols. 178-181, pp 2654-2657
doi:10.4028/www.scientific.net/AMM.178-181.2654

Design of Intelligent Vehicle Security and Immobilization System

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Keywords: Tire Pressure Monitoring System, Remote Keyless Entry, Immobilization

Abstract. An integrated system is proposed of base station module, key module and tire modules, in order to overcome the independence of tire pressure monitor system, remote keyless entry and immobilization of engine. Tire modules or key module communicate base station module with UHF frequency signal of 434MHZ. The transponder PCF7961 in key module and PJF7992 in base station module authenticate mutually with LF frequency signal of 125KHZ. The result is shown that the system can improve the security and controllability of cars, compress system redundancy, reduce produce costs and optimize the skeleton network.

Introduction

It is necessary to develop safety and security systems of car, because traffic accidents and car thefts frequently occur [1-2]. The system is proposed, that incorporates a tire pressure monitoring system, remote keyless entry system and immobilization system. It can reduce hardware costs and improve the integration of system.

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System Design

The integration system consists of tire modules, key module and base station module, as is shown in Fig. 1. The system is generally composed of four tire modules, a key module and a base station module. The base station module composes of the RF receiver, LF transceiver, the central control section, man-machine interface, and LIN bus. Tire modules are installed in the car's tires. It measure and send real-time measurements of tire's pressure, temperature and battery voltage parameters to the base station through the RF communication. Base station module receives the RF data from tire modules. Then, it determines whether the tire parameters are normal or not. If the parameters are abnormal, base station module will alarm. Also, base station module receives the RF data from the key module, and verifies the legality of the ID of the key. Base station performs relevant operation, if key is right. The immobilization communicates with the transponder in the key model with the LF signals. The engine is able to ignite, if the password of transponder and base station matches.

Tire module consists of the tire parameter acquisition and transmission circuit, as is shown in Fig. 2. The embedded sensor MPXY8300 is designed of FREESCALE. MPXY8300 is composed of low-power S08 core, 512 bytes of RAM and 16 KB Flash (8 KB for firmware including underlying driver, the test program and fixed data, etc). Also, it integrates a low-power capacitive pressure, temperature sensors, and low-frequency input interface. The RF circuit of MPXY8300 can work with 315MHz and 434MHz carrier frequency. Moreover, it can be configured in the mode of amplitude shift keying (ASK) or frequency shift keying (FSK) modulation. It also integrates a charge pump, that can improve the RF transmitter power supply voltage when the battery voltage is low. MPXY8300 is

a system on chip that is composed of pressure sensors, temperature sensors, integrated on-chip 8-bit microcontroller, RF transmitter and dual-axis accelerator. The pressure measurement range of MPXY8300 is from 100 to 800 kPa in cars and from 100 to 1400 kPa in trucks [3].

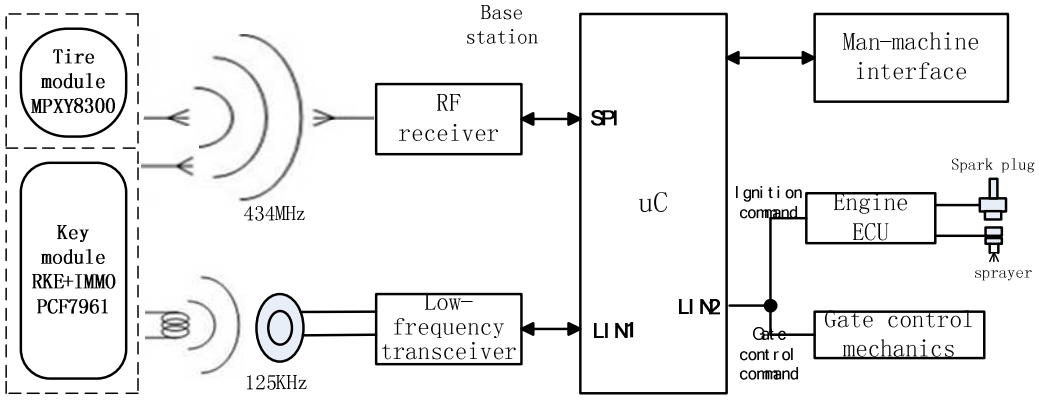

Fig. 1 The block diagram of the whole system

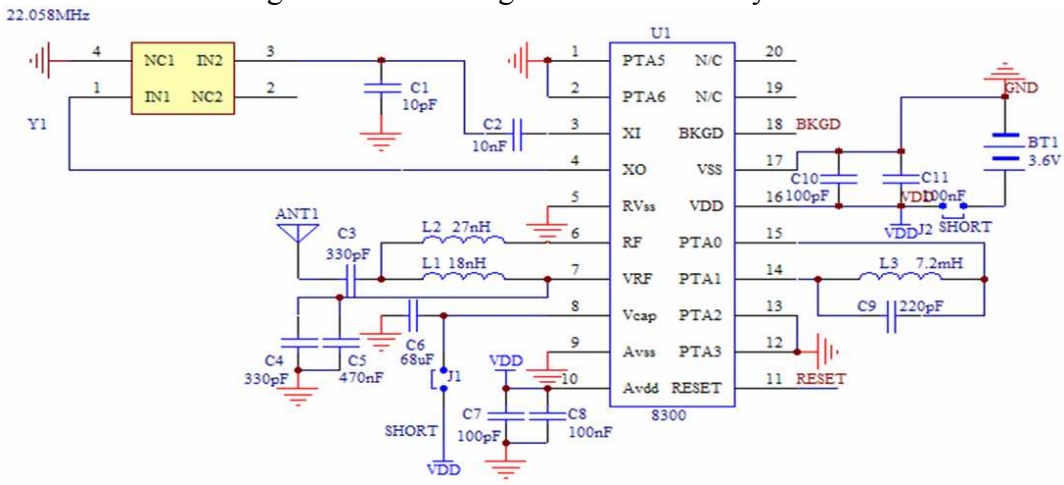

Fig. 2 Tire module circuit

The key module is designed of PCF7961 [6]. PCF7961 is a reduced instruction set (RISC) processor of low-power 8 bits MRKII architecture. It integrates a UHF transmitter and LF frequency transponder. The chip is able to transmit RF carrier and low frequency communication authentication. It is designed to realize remote control and anti-theft of motor vehicles. It has advantages of fast mutual authentication algorithm, random number key and password, with high sensitivity and short identification of 39ms. Also, PCF7961 provides 32 bits identification code in factory. The schematic circuit of the key module is shown in Fig. 3.

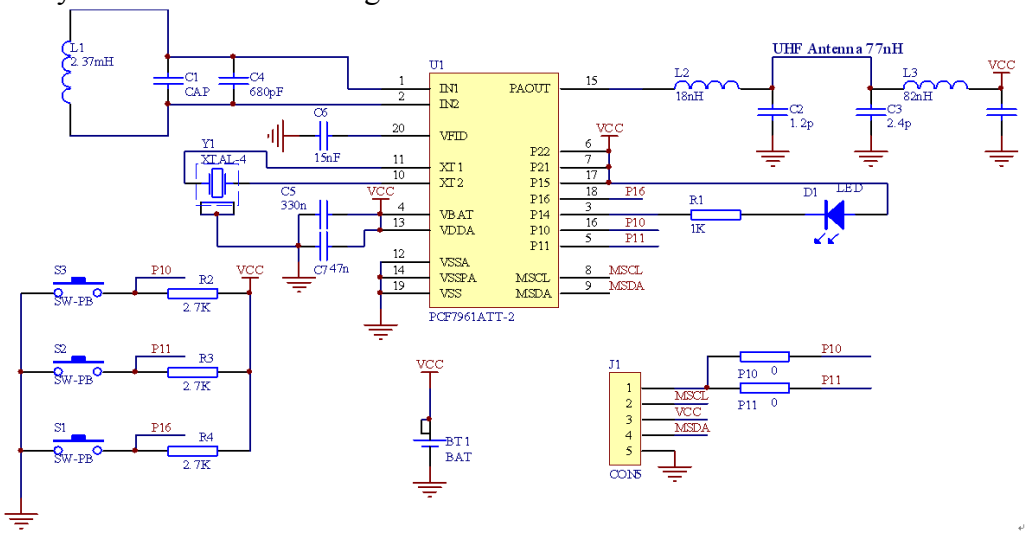

Fig. 3 Key module circuit

The base station module is designed of RF receiver circuit, the circuit of the low-frequency transceiver, microcontroller, LIN interfaces, as well as man-machine interface. RF receiver circuit is designed of MC33596 to demodulate and decode in Manchester. The decoded data is sent to microcontroller to decrypt and execute instruction.PJF7992 is selected as Low-frequency transceiver. The microprocessor of base station communicates with PJF7992 by the LIN bus interface. The microcontroller is designed of MC9S08DZ60, which communicates MC33596 with SPI bus. It integrates two LIN modules. The first one manages the transceiver chip PJF7992. The second controls the engine electronic control unit and gate, etc.

Software design

FSK modulation and Manchester encoding are used in the system. The data frame formats of tire modules and key module are shown in Table 1 and Table 2.

Table 1 Tire module RF data frame format

Data content	Leading bits	Header	Tire ID	Pressure	Temperature	Voltage	Status	Sum check
Bits	24	16	32	8	8	8	8	8

Table 2 Key module RF data frame format

Data content	Leading bits	Header	Key ID	KEELOQ	encrypted data	Sum check
Bits	24	16	32	32	32	8

Tire modules do not detect tire parameters while car stops, in order to maintain low power consumption. The flow chart of tire module is shown in Fig. 4. The microprocessor initiates system configurations, while system power-on reset. In normal operating conditions, the microprocessor measures acceleration of the car, then determines the car operating status. Microprocessor comes into sleep mode, if the speed is low than 25km/h. On the contrary, the car comes into the normal operating mode, and detects all the parameters then emits to base station.

Driver can open and close the door by click the button switches on the key. The key module sends RF data to base station. Rolling code encryption is used to ensure security. The flow chart of key module is shown in Fig. 5.

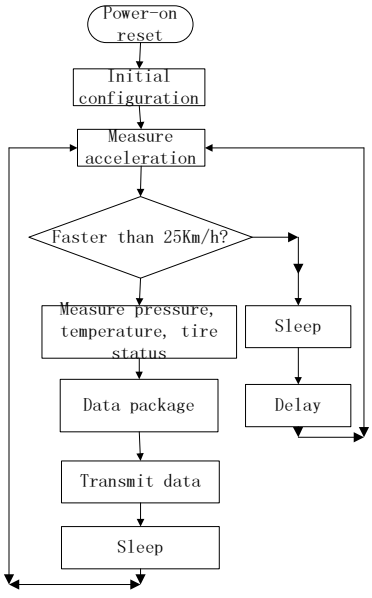

Fig. 4 The flow chart of tire module software

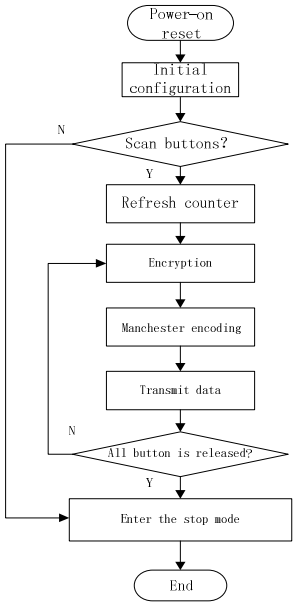

Fig. 5 The flow chart of key module software

The base station module receives tire modules data frame, and displays all the tire parameters. At the same time, the base station module monitors control commands of key module, and operates accordingly. The transponder in key and base station modules PJF7992 authenticate mutually, while the key inserts into the ignition lock and rotates to the start position. If they authenticate correctly, the command is sent to LIN bus, then the engine ignites. The software flow chart is shown in Fig. 6.

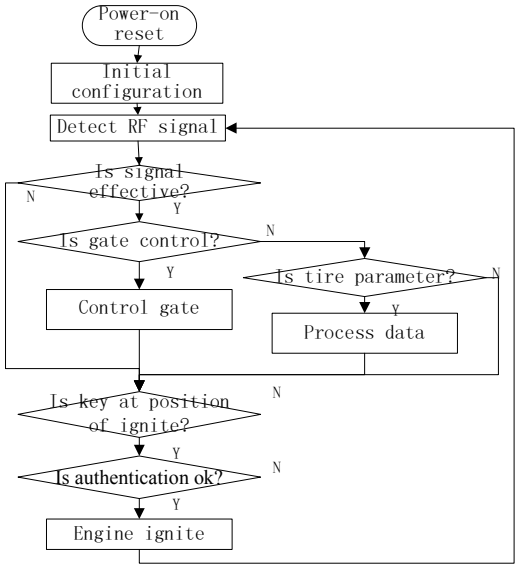

Fig. 6 The flow chart of base station module software

Conclusion

In this paper, a car security system is proposed of tire pressure monitoring, remote keyless entry and engine immobilization. LIN bus interface of the system, can share data and control information with electronic control systems. The system is flexible and secure, space savings, lower production costs. The system can be used in automotive electronics widely.

Acknowledgements

This work is supported by Scientific Research Fund of Hunan Provincial Education Department (11C0410).

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