Design and Implement Circuit of Wireless Charging of Parking Management System

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Abstract. This paper presents a designing and implementing circuit of wireless charging of the parking management system based on Radio frequency identification (RFID) technique and STM32F103 as the control kernel. The advantage of digital modulation technique in applied radio signals is used to identify specific targets and read-write relevant data. Communication is established between the parking space reader and the onboard responder. Parking time and power consumption collected by a peripheral circuit of STM32F103 are connected to a computer through means of the modulation technique of digital frequency modulation FSK with data duplex communication. The host computer processes the received owners' parking data and shows the results on the terminal display screen. The cost of charging power and parking time is settled automatically by a remote payment system through the network interface using protocols like TCP/IP. Moreover, if some abnormal conditions occur, the host computer can initiate a sound-light alarm automatically to notify field staff. The tested new circuit design shows that the proposed scheme is a practical tool.

Keywords: Radio Frequency Identification, Wireless Charging, Parking Management.

1 Introduction

The electric automobile wireless charging technique is an energy transmission process by using indirect-contact wireless charging. It can use in the supply of the kinetic energy of electric automobiles with the advantages of operation safety, reliability, intelligent charging, and flexible allocation [4]. However, some bottleneck effects put limits on the studies. Due to the short distance of endurance, as well as other factors, it is hard to realize mass production. Currently, there are many chaotic phenomena in parking management with non-standard and unreasonable conditions, such as the arbitrary charge [2]. In this paper, we design and implement a circuit wireless charging of the parking management system based on Radio frequency identification (RFID) technique and STM32F103 as the control kernel to deal with the mentioned limitations.

2 Composition of Wireless Charging of Parking Management System

Wireless charging parking management system consists of three parts, as shown in Fig ure 1: the wireless charging stations in (a)~(c), and slave-computers installed under th e parking spaces. Slave computers consist of an FSK digital frequency modulation wir eless transmission duplexer and parking space RFID reader, (d) is the RFID responder and onboard wireless charging circuit installed under the cars. The host- computer in (e) has an FSK digital frequency modulation wireless transmission duplexer, a data pro cessing center, terminal data display, and emergency alarm, and uses the internet to ca lculate of cost in the payment system automatically.

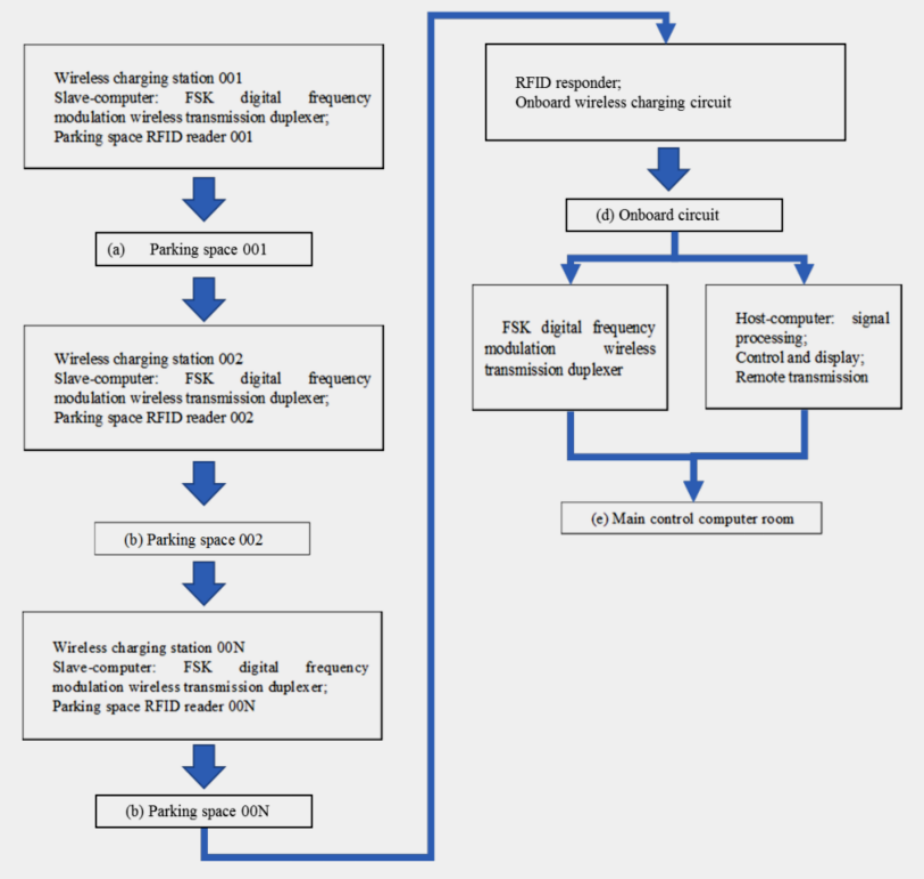


Fig. 1. Wireless charging parking management system

2.1 Design Introduction of the Wireless Charging Circuit

A wireless charging circuit is shown in Figure 2(a). It consists of four parts: an oscillation signal generator composed by IC1 NE555, a triode VT6 amplifying circuit, a high-power drive circuit module and a triode VT7 C-class resonate power amplifier. Oscillation signal generator composed by NE555. Using the NE555 to form oscillation frequency circuit, the estimation formula of oscillation frequency is shown as below:
Operation frequency:

$$f_0 = 1.443/(RP_1 + R_{30} + 2R_{31}).C_{35,} \quad (1)$$

where the unit of C_{35} is uF, the unit of electric resistance is KQ, and the unit of frequency is KHz. The f0 selected is generally between 110 KHz and 220 KHz, which has small radiation to human body.

Power amplifier circuit. As shown in Figure 2(a), the power amplifier circuit consists of the front-load power amplifier VT6, high power drive circuit module and VT7 C-class power amplifier. Electric resistors R32 and R33 are the base biasing resistors of front-load power amplifier VT6. Capacitor C38 is the emitter bypass capacitor. Resistor R34 is DC negative feedback emitter resistor. Collector loop high-frequency transformer T3's primary coil and variable capacitor C39 have been modified to resonate at the center frequency f_0MHz. High-frequency transformer T3，s secondary coil's high-frequency signal is separated by capacitors C40 and C41 and is then amplified in the high-power drive circuit module. The amplified signal is transferred to C-class amplifier VT7 through capacitor C42, and then is amplified again. Variable resistors RP2 and R35., and electrolytic capacitor C43 provide negative bias-voltage adjustment circuit for C-class amplifier VT7's base. Electrolytic capacitor C43 is a filter capacitor and resistor R37 is an emitter DC negative feedback resistor. C47 is a bypass capacitor. Inductor L6 separates current for the high-frequency choke coil to stop high-frequency signal, ensuring that the DC voltage can be added on the base electrode of triode VT7. Variable resistor RP2 can change the negative bias-voltage of C-class amplifier VT7's base electrode to increase the efficiency of C-class amplifier. The amplified high-frequency signal can be stored as magnetic field energy on coil L7 [3] and then be radiated to outer space in the form of electromagnetic wave.

2.2 Onboard Wireless Charging Circuit

The onboard wireless charging circuit is shown in Figure 3. Electromagnetic wave receiving coil L8, capacitor C49 and variable capacitor C48 compose the LC resonance circuit that resonates at the center frequency f_0 sent from the wireless charging station in Figure 2. Transfer between electromagnetic wave and AC voltage is realized on the two sides of coil L8 [6][7]. After rectification by bridge rectifier diode VD12-VD15 and filtering by electrolytic capacitor C50, AC voltage is transformed to DC voltage. It charges the storage battery through resistor R39. Resistor R38 and LED VD16 form the power indicator circuit.

2.3 Study on Wireless Charging Station Circuit

With the development of science and technology, people have expanded their knowledge of the properties of electromagnetic waves, which cannot be touched and seen. This system circuit's parking space charging station transfers DC energy to electromagnetic wave energy, and the onboard charging circuit transfers electromagnetic wave energy to DC energy. Although wireless charging provides great convenience to people, its low efficiency is not acceptable by them. Current commercial wireless chargers are mobile wireless chargers with low power, while the market of automobile wireless charger is still at the early development stage. There are some questions to be answered [5]: (1) How to further improve charging efficiency of the wireless charger; (2) What frequency of electromagnetic wave should we adopt in the process of close range electromagnetic wave energy transfer, to get maximum efficiency and low radiation effect to human body; (3) There are many circuits to realize electromagnetic wave energy transfer. This circuit is just one of them. Which circuit is the optimal one; and (4) Which materials should we choose for the varnished wire of the transmission coils and how to wind them, to get the most concentrated electromagnetic wave energy and the highest efficiency, and to be most helpful for the study of energy transfer between electromagnetic wave energy and AC. We need to study further, to launch the products as soon as possible.

3 Design of an RFID wireless transmission circuit

When we design the circuit, we need to consider the following factors: if the total number of parking spaces is Y, the number of installed onboard responders and wireless chargers is X, and 80% of the owners will park their cars in this parking lot during the peak period, then X*80%=Y. When we implement binary coding with a unique number for each car [1], we should include all information of the owner. Binary coding element should be able to include the license plate number and bank account number as needed. It should also have adequate redundancy to increase capacity in the future. All the coding information of owners should be recorded in the chip STMF103 in each parking space reader.

3.1 Design of an RFID Wireless Transmission Circuit

The operation principle: As shown in Figure 3(a), when the owner parks the car in the parking space, using the parking space sensor to drive the parking space reader allows all the information of the owner to be sent out with a unique pack of serial digital signals for each of them and with the ASK modulation mode. Send out each owner's information from STM32F103 45# with a 20ms time interval, and after sending all the owners' information, wait for 40ms for the signal of the responder and then repeat the circulation. The output signal from IC3 45# is transferred through the capacitor C28 to ASK modulation triode VT4's emitter. The crystal oscillator, acting as carrier wave, is transferred to emitter follower VT5's base electrode through capacitor C22 and its

power is amplified. Then it is transferred from emitter capacitor C20 to ASK modulation triode VT4's base electrode, to conduct amplitude modulation. After that, it is amplified through triode VT4 by single tuning, and the primary inductor of high- frequency transformer T2 and variable capacitor resonate on the crystal frequency. The secondary T2 is separated through capacitors C15 and C16 and then is amplified by the last power amplifier VT3's base electrode. Similarly, the primary coil of high- frequency transformer T1 and variable capacitor C14 resonate on the crystal frequency, and high-frequency digital amplitude-modulated wave is sent out from the secondary coil of T1.

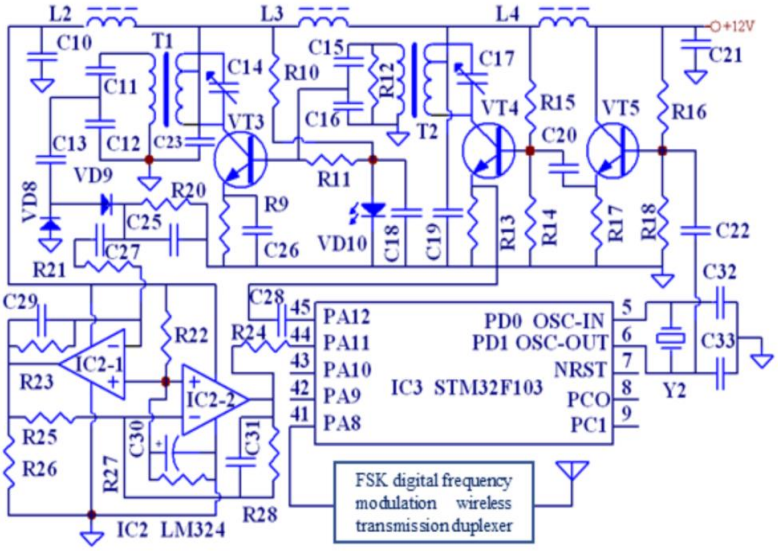


Fig. 2. RFID wireless transmission duplexer- circuit of the reader

3.2 Onboard Responder

As shown in Figure 3(b), inductor L1, and capacitor C1 and C2 resonate on the crystal Y1 frequency of figure 3(a) and receive the amplitude-modulated signal of ASK.

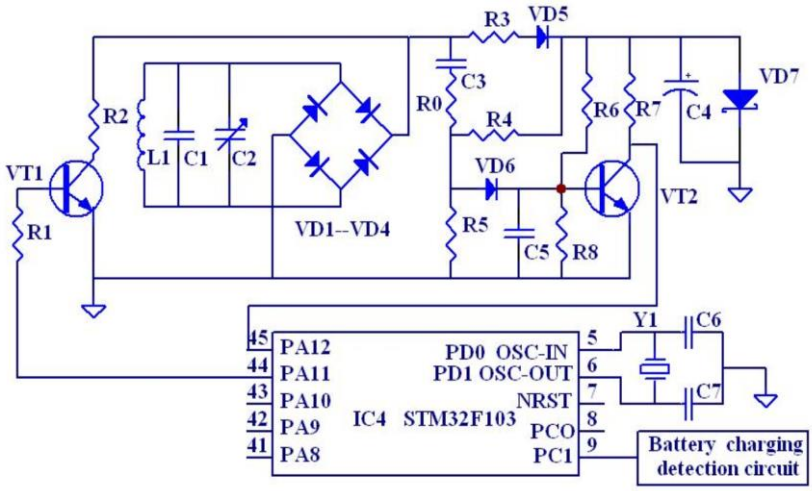
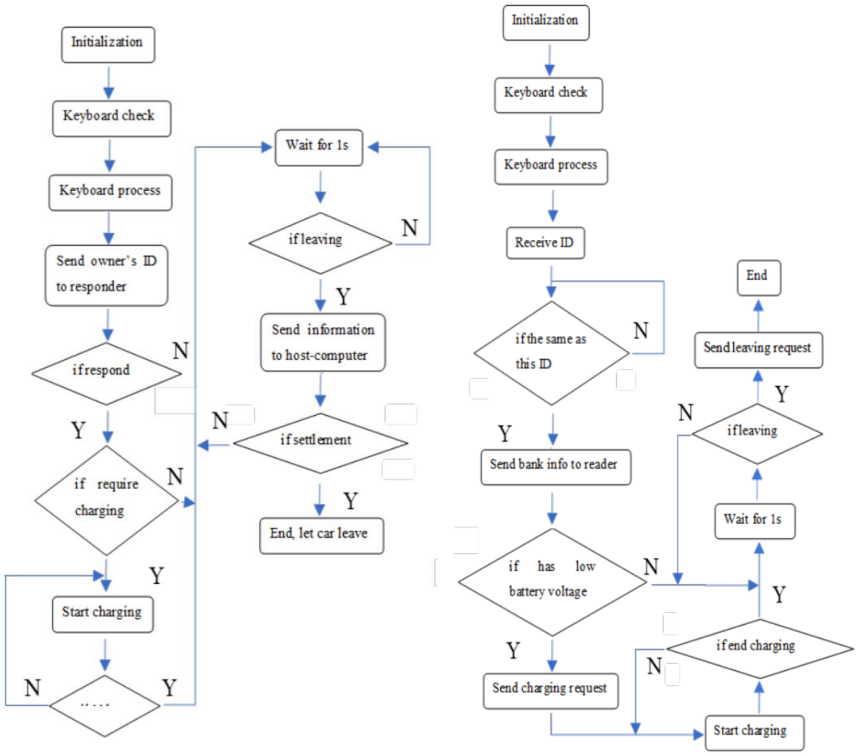


Fig. 3. RFID wireless transmission duplexer- circuit of the responder

Through the bridge-type high-frequency rectifier diodes VD1-VD4, the output of capacitor C3 from top to ground is the positive ASK impulse wave voltage, and it is coupled to the two ends of R5 though capacitor C3 and resistor R0. Resistors R4 and R5 provide the initial bias voltage to diode VD6 and keep it in a micro-conducting state. After demodulation by diode VD6 and capacitor C5, the owner's binary coding is exported, which is amplified through triode VT2 and exported to IC4 STM32F103 45# through the collector. When the collected binary coding information is the same as the

chip information stored in the current onboard IC4, IC4 immediately transfers the binary coding information such as the owner's bank account number from IC1 44# through resistor R1 to triode VT1's base electrode for amplification. After amplification and phase inversion from the collector, it is then transferred to bridge-type high- frequency rectification diodes VD1-VD4 that constitute the output terminal. This realizes the modulation of ASK and transmission from coil L1. Similarly, for the battery charging detection circuit, when the voltage is relatively low, the charging is finished, or the owner leaves the parking space, IC1 44# will send out a serial of binary coding digital information of the owner, which is amplified through triode VT1, modulated by bridge type diode ASK and sent out from coil L1.



a) Design block of reader

b) Design block of responder

Fig. 4. Portion of software design blocks

3.3 Information Receiving by Parking Space Reader

As shown in Figure 4(a), diodes VD8 and VD9, resistor R20, and capacitor C25 compose the ASK voltage-multiplying detector circuit. After the ASK amplitude- modulated signal is received by the onboard responder, it undergoes demodulation in the previous voltage-multiplying detector circuit to form binary digital signal. Then it is amplified and modified through IC2-1 and IC2-2 reverse operational amplifiers and sent into IC3 STM32F103 44# to undergo data processing of digital signal. After that, it is exported from #41 to FSK digital frequency modulation wireless transmission duplexer and emitted after modulation.

3.4 Main Computer Control Room

When the FSK digital frequency modulation wireless transmission duplexer, installed on the host computer in the main control computer room, receives the FSK signal from the parking space reader, the signal is demodulated and transferred to the host computer to process data and export from two paths. Through one path, the signal is sent to the display terminal to show the field information. If any abnormal phenomenon happens, it will send out automatic sound-light alarm and get immediate management. Through the other path, the signal is sent through Internet network to realize the automatic settlement of the cost in the remote payment system by protocols like TCP/IP.

4 Software Design

This software design cooperates well with the hardware circuit. In the communication process between the host-computer and slave-computers, it considers the owners' cost conditions at the parking lot. It can conduct automatic conversion of owners' parking duration and charging energy consumption to the cash amount. It also adopts the TCP/IP protocol of the host-computer to establish telecommunication with the Internet and alizes the automatic settlement of the cost with contracted payment platforms. A portion of the software design diagram is shown in Figure 4, which demonstrates the design idea of the wireless charging parking management system software.

5 Conclusion

In this paper, we presented a designing and implementing circuit of wireless charging of the parking management system. Charging principles of the wireless charging station and parking management were used in the detailed design for dealing with bottleneck effects such as a lousy cruising ability and inconvenient wire charging stations. The modules as the components of the system are wireless communication among parking

space reader, onboard responder, peripheral circuit, and computer. Client cost settlement with distance contracted account banks was calculated for payment that transmission is transferred through the Internet. The host computer can initiate a sound-light alarm automatically to notify field staff if some abnormal conditions occur. The tested new circuit design shows that the proposed scheme is a practical tool.

6 References

1. Guo W.T. and He Y.G. .The Research and Design of Management System of Intelligent Parking Based on RFID. Techniques of Automation and Applications. 29(6).(2010)
2. Chen Z.H., and Yan G., Current Situations and Development Trends of Intelligent Parking Industry. Intelligent Building 4, (2014).
3. Qu Z.J. , Wang X. P. et al. Analysis of Wireless Charging Circuit for Electric Vehicle. Journal of Shijiazhuang Tiedao University (natural science edition), 2, (2014)
4. Zhang B.Q. and Li X. L. Current research and practical analysis of contactless charging in electric vehicles. Electronic Measurement Technology. 35(3). (2012)
5. .Zhu C.B. ,Jiang J.H. et al.Research Progress of Key Technologies for Dynamic Wireless Charging of Electric Vehicle. Automation of Electric Power Systems. 41(2). (2017)
6. Chao L.L.,Chen H.H. et al. Review of the Efficient Wireless Power Transmission Technique for Electric Vehicles. 27(08). (2012)
7. V. Nair, Vijith, and J. Choi, An efficiency enhancement technique for a wireless power transmission system based on a multiple coil switching technique, Energies vol. 9, no 3 , pp. 156.(2016)