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Design of RFID Reader Based on MCUMSP430*

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Abstract: Saving power is an important problem in portable device. This paper presents a SOC (System on a Chip) system for radio frequency identification (RFID) reader to simplify the complex traditional circuits. It puts the peripheral circuits into SOC and uses software to execute the decoding, checking, identifying and real-time calculating and displaying of digital signals. The proposed system has advantages such as simple structure, low cost, and low power consumption.

Key words: RFID; reader; low power consumption
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1 Introduction

RFID is one of automatic technology to identify and collect object data quickly through RF digital signals. RFID increases productivity and convenience. RFID is used for hundreds, if not thousands, of applications such as preventing theft of automobiles and merchandise, gaining entrance to buildings, automating parking[1], and so on. The thoughts of RFID occurred on the heels of the development of radar. An early, if not the first, work exploring RFID is the landmark paper by Harry Stockman, "Communication by Means of Reflected Power" published in 1948[2].

RFID has advantages over bar code[3]: RFID does not require line-of-sight access to read the tag; the read range of RFID is larger than that of a bar code reader; readers can simultaneously communicate with multiple RFID tags; because of this capability, a RFID reader can capture the contents of an entire shipment as it is loaded into a warehouse or shipping container; a reader collects detail information in one pass, without having to scan each product; tags can store more data than bar codes.

In general, RFID system comprises a reader (or interrogator), its associated antenna and the transponder (or tag) that carries data (see fig. 1). Depending on their source of electrical power, there are active and passive two general categories. Active RFID tags contain an on-board battery. Passive tags obtain power from the signal of reader. This paper deals with the passive-tag reader of 125 kHz.

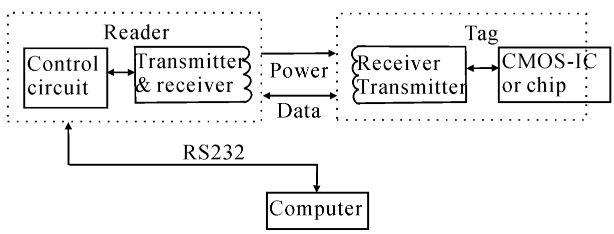

Fig. 1　Block Diagram of a General Passive RFID System

The reader is usually controlled by micro controller of MCS51 or arm. The former has high voltage, and much pow-

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er consumption, with many peripheral circuits in the control system of RFID reader. It is not convenient to adjust the system and the area of PCB is big. The latter has high price, and the control system is complex. This paper presents a RFID reader system based on MSP430, which puts much peripheral circuits into a chip. It uses software to execute the decoding, checking, identifying and real-time calculating and displaying of digital signals. The proposed system has advantages such as simple structure, low cost, and low power consumption.

2 Functions of System

2.1 The Passive-Tag Reader

The reader is composed of RF.-Module and micro controller (see fig. 1). The reader transmits a low-power radio signal through its antenna of RF.-Module. When a tag comes within the reader's range, it receives an electromagnetic signal from the reader through the tag's antenna. The tag then stores the energy from the signal, a process called inductive coupling[3]. When the tag has built up enough charge, it can power a back-end integrated circuit (chip) of the tag, which transmits a modulated signal to the reader. That return signal contains the information stored in the tag. Once the RF.-Module received the data it can be sent to a micro controller (or computer) for processing and management. At the same time, the processed data will be sent to LCD for display.

2.2 Communication Between Reader and Tag

Biot-Savart laws establish the relationship between the current I_1 flowing in an electrical circuit having length l and the intensity of the magnetic induction B as function of the distance x between the measurement P point (of unit vector z, shown in fig. 2) and the element dl producing the field according to the formula[4]:

$$dB = \frac{\mu_0(I_1 \cdot dl) \times e_z}{4\pi x^2}.$$

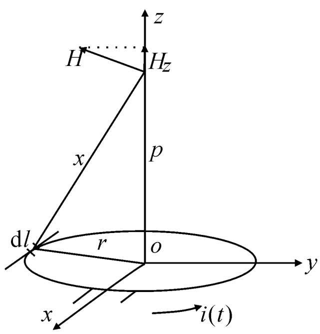

Fig. 2 Magnetic Field Strength (the Axis of the Coil)

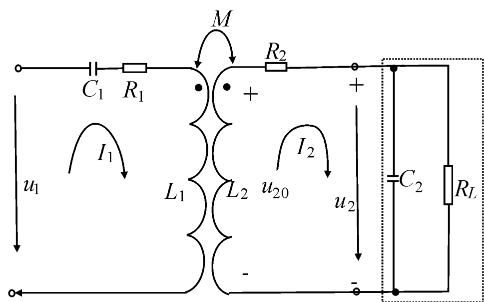

Fig. 3 Electric Equivalent Circuits for Magnetic Coupling of Reader and Tag

z is the axis of the coil. The total intensity of the magnetic induction of reader antenna is:

$$B_z(d, r) = \frac{\mu_0 N_1 I_1 r^2}{2(r^2 + d^2)^{3/2}}.$$

The electric equivalent circuit for Magnetic Coupling of Reader and tag is depicted in fig. 3. As the previous section has shown, this system works on the principle of Magnetic Coupling. The reader antenna resonant circuit is constructed by a capacitor C_1 with an inductance L_1 and the resistance R_1. The circuit of tag antenna is simplified as L_2, R_2, with the capacitance C_2, and the data load R_L[4]. Where parameter I shows the current of antenna; U_1 is the source of ac signal voltage; U_2 is the load voltage. The subscript 1 indicates the side of reader; the subscript 2 denotes the side of tag.

The voltage of reader antenna is $U_1 = \omega L_1 I_1 = \omega\Phi_1$. When tag enters the field of reader, such as P point, the flux that goes through tag antenna is $\Phi_2 = B_Z S_2 N_2$. According to Faraday's Law, if $\Phi_2(t) = B_Z S_2 N_2 = \Phi_2 \sin(\omega t)$, then $u_{20}(t) = -d\Phi_2(t)/dt = \omega\Phi_2\cos(\omega t)$. Value of the coupling coefficient is $M = k\sqrt{L_1 L_2}$. The relation of signal voltage between reader and tag antenna is: $U_{20}/U_1 = k\sqrt{L_2/L_1}$.

3 System Architecture

3.1 Reader System

Reader system frame is consisted of RF.-Module, LCD, keys, MCUMSP430 and power. Reader system frame of MSP430 is shown as in fig. 4. This system uses low-power consumption MCUMSP430 that is a system on chip as the controller. The voltage is at 1.8~3.6 V. 3 V is chosen by this system. The MSP430 ultra low-power architecture extends battery life. Current of RAM retention is 0.1 μA; a real-time clock mode current is 0.8 μA; current of active state is 250 μA/1MIPS. The clock system is designed specifically for battery-powered applications. A low-frequency auxiliary clock (ACLK) is driven directly from a common 32 kHz watch crystal. The ACLK can be used for a background real-time clock self wake-up function. This low-frequency auxiliary clock makes stand-by mode ultra low-power. An integrated high-speed digitally controlled oscillator (DCO) can source the master clock (MCLK) used by the CPU and high-speed peripherals. By design, the DCO is active and stable in less than 6 μs. This high-speed master clock achieves high performance signal processing. MSP430-based solutions effectively use the high-performance 16-bit RISC CPU in very short bursts.

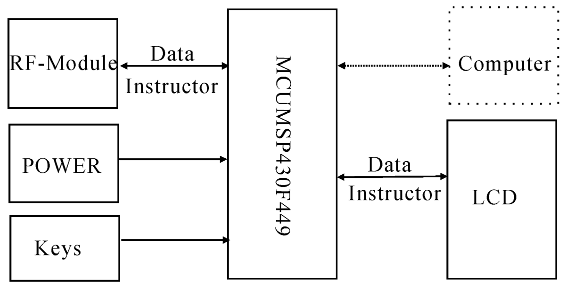

Fig. 4　Reader System Frame of MSP430 F435

MSP430 has LCD controller, which can directly drive LCD displays. It simplifies the complex circuits of traditional electrical LCD display system and solves the additional error problems. It puts the peripheral circuits into SOC. This can reduce the area and power consumption of PCB and minify the portable RFID system.

Fig. 3 shows RF.-Module communicating with MCUMSP430. It can be seen that LCD module is linked with MSP430 by I/O in fig. 3. LCD gets data from I/O of MCUMSP430 and then displays them. When there is tag in the reader radio field, RF.-Module will receive signals. At the same time, the interrupt will wake up CPU in less than 6 μs. Then CPU processes data and LCD displays them. When CPU has operated the interrupt, it will be set in the ultra low-power stand-by mode by the software. If there is not tag for a long time, LCD display is set to low power state. There are 20 keys in this system, which are linked with CPU. RF.-Module and Keys are connected with the interrupt pins. If there is no interrupt signals, system are in low-power state. The soft frame is shown in fig. 5 and fig. 6.

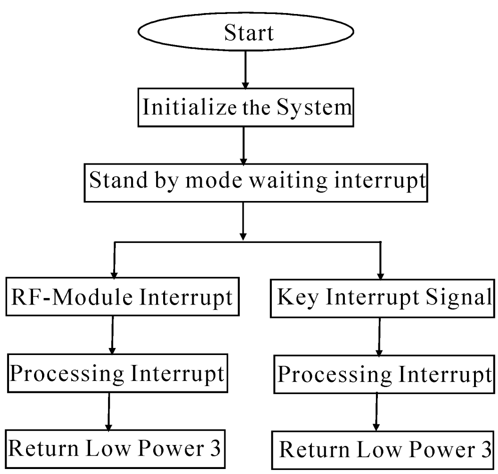

Fig. 5　Reader System Software Frame

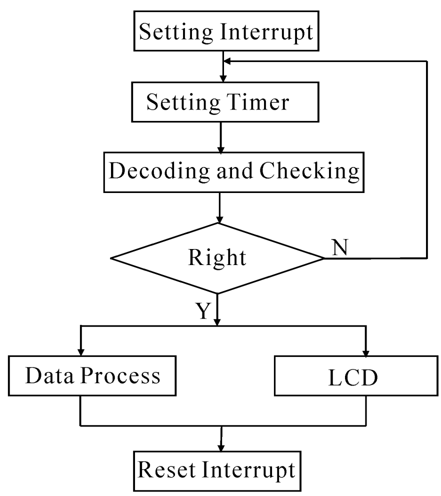

Fig. 6　Identification Subprogram of Interruption

3.2 Communication Between RF.-Module and MCU

The communication between RF.-Module and MCU is as in fig. 7: There is one byte as the start data and one byte as the end data. The middle part is the ciphered data and longitudinal redundancy check (LRC)[5] data. RF.-Module data and LRC data are sent together to the MCU. When their XOR result is zero, the data is right. Then data are sent to LCD for display, decoding and processing them. For example, one tag ID number is 51E2066CED. Their ciphered codes are 35H, 31H, 45H, 32H, 30H, 36H, 36H, 43H, 45H, and 44H. Longitudinal redundancy checksum is (51H) XOR (E2H) XOR (06H) XOR (6CH) XOR (EDH), and the checksum equals 34H. Together with the start bit 01, ciphered data, checksum and stop bit 02, the total number is 01 35 31 45 32 30 36 36 43 45 44 34 02. If MCU MSP430 gets the data, it must take out the ciphered data with the checksum data, and execute the longitudinal redundancy check. If the checksum of MCU is zero, it will decode the ciphered data. Identifying, real-time calculating and displaying of digital signals must be carried out. If the checksum of MCU is not zero, this means that there are some errors in the data. Then MCUMSP430 will ask the RF.-Module to send the data again.

start bit	Ciphered data	Checksum	stop bit

Fig. 7 Data Form Between RF.-Module and MCU

If MCU wants to get data correctly, it must apply with the data timing as fig. 8. Clock frequency must be set seriously, and the time of instructors must be calculated correctly. Or else, experiment data may be wrong. It will take a lot of time to adjust and do experiments.

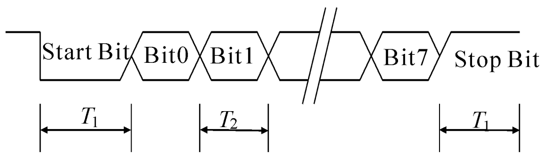

Fig. 8 Data Timing

4 Experiments

Table 1 shows power consumption of CPU and system at different state. When CPU is at stand-by state, current is the active state's 39.2%. Power consumption of the stand-by state can be reduced to 61% of the active state.

Table 1 CPU Power Consumption of 125 kHz RFID System

CPU State	CPU I/mA	Power Consumption/mW
Active	0.028	0.616 00
Stand-by LP3	0.011	0.024 20
Sleeping	0.010	0.000 22

5 Summary

This paper presents a RFID reader system for 125 kHz to simplify the complex circuits of traditional system and to solve the additional error problems. It puts the peripheral circuits into SOC and uses software to execute the decoding, checking, identifying and real-time calculating and displaying of digital signals. The proposed system has advantages such as simple structure, low cost, and low power consumption. This system is successfully used in 125 kHz RFID.

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Teleportation of Two-Partite Arbitrary States Via Genuine Four-Partite Entangled States

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Abstract: A scheme for teleportation of two-partite arbitrary states via genuine four-partite entangled states is proposed. In the scheme, 16 orthogonal and complete bases are constructed. All the bases are genuine four-partite entangled states, none of which is reducible. The scheme reveals some particular properties of the related four-partite entangled state, and indicates that in some sense the amount of entanglement of two Bell states can be abstracted from any one of the four-partite states.

Key words: four-partite entangled states; two-partite arbitrary states; orthogonal and complete bases; teleportation

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基于MSP430控制的射频识别读写器设计

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摘 要: 设计了一种基于单片机处理器的射频识别(RFID)便携式读写器的系统. 采用当前先进的片上系统(System on Chip, SOC), 将外围电路尽可能地放置于SOC芯片内, 利用软件实现了对射频标签信号的数字实时采集和控制功能, 从而简化了传统的微控制器控制的RFID读写器所需的庞大硬件电路及其引入的额外误差, 具有重要的实用价值, 并且功耗和成本很低.

关键词: 射频识别; 读写器; 低功耗
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