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Design of RFID Reader Based on Protocol of ISO/IEC 15693

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Abstract. In recent years, the technology of RFID developed rapidly, and has been used more and more widely. In this paper, using the Texas Instruments semiconductor chip of TRF7960 and the single-chip microcomputer of PIC16F877, a new design scheme of RFID reader is proposed, which conforms to ISO/IEC 15693 standard. The reader operates in 13.56MHz and can identify the tags in about fifteen centimeters. The hardware design and the software flow are provided in detail. Test results present that the functions of anti-collision and multiple tag identification are supported in this reader, it has high accuracy ratio when reading and writing tag.

Introduction

The TRF7960 is a high-performance 13.56MHz HF RFID reader IC of Texas Instruments comprising an integrated analog front end (AFE) and a built-in data framing engine for ISO15693, ISO14443A and ISO14443B. Other standards and even custom protocols can be implemented by using two of the Direct Modes the device offers. These Direct Modes (0 and 1) allow the user to fully control the AFE and also gain access to the raw sub-carrier data or the unframed, but already ISO formatted data and the associated clock signal [1]. So it is used extensively in secure access control, product authentication, contactless payment systems, medical systems, and other applications [2].

In this paper, after introducing characteristics of RFID tags and TRF7960, design process of the RFID reader is put forward in detail, and with application tests, feasibility of this design is proved.

Design scheme of RFID Reader

RFID Tag. Texas Instruments Tag-it™ HF-I plus transponder IC offers a full 2048 bits of user memory, Each of the 64 pages has 4 bytes, can be individually read, programmed and locked. The Read Only Unique ID (UID) is accessed using the "Inventory" command and this value can be used to address individual tags. which is defined by the ISO/IEC15693 standard and contains two mandatory bytes to indicate that it is an ISO15693 device (MSByte = 0xE0) and the manufacturer of the silicon (next MSByte = 0x07 = TI) [3].

Another tag is Philips I·CODE SLI Transponder IC, which only offers a 896 bits of user memory, each of the 28 pages also has 4 bytes. The structure of UID is the same as Tag-it™ HF-I plus transponder IC, and the value of next MSByte is 4, indicating that the manufacturer is Philips [4].

Characteristic of TRF7960. TRF7960 has three work modes, as shown in Fig. 1.

In mode 0, TRF7960 allows the user to use only the front-end functions, bypassing the protocol implementation. For transmit functions, the user has direct access to the transmit modulator through the MOD pin (pin 14). On the receive side, the user has direct access to the sub-carrier signal (digitized RF envelope signal) on I/O_6 (pin 23). mode 1 uses the sub-carrier signal decoder of the selected protocol (as defined in ISO control register), framing is not done. This means that the receive output is not the sub-carrier signal but the decoded serial bit stream and bit clock signals. The serial data is available on I/O_6 (pin 23) and the bit clock is available on I/O_5 (pin 22). The transmit side is identical, the user has direct control over the RF modulation through the MOD input. In mode 2, data is ISO-standard formatted, so the microprocessor receives only bytes of raw data via a 12-byte FIFO. Usually, mode 0 and 2 are adopted to implement the ISO/IEC 14443 Type A standard of RFID.

The communication interface to the reader can be configured in two ways: a parallel 8-pin interface or a serial peripheral interface (SPI). it has an IRQ pin to prompt the MCU for attention if it detects a response from the proximity integrated circuit card (PICC).

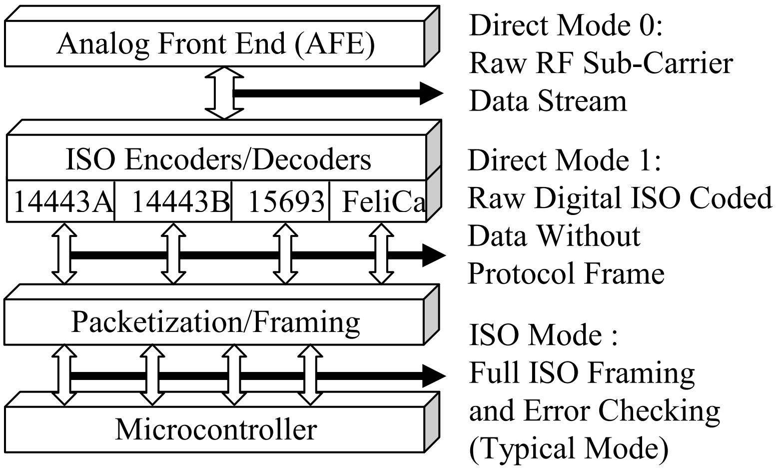

Fig. 1. User-configurable modes

Structure of the RFID Reader. Structure of the RFID reader is as Fig. 2 shown, which is composed of main controller that PIC16F877, RFID reading and writing chip that TRF7960, LCD, Personal Computer(PC) and power module. The single-chip microcomputer that PIC16F877 is communicating with TRF7960 through the SPI interface.

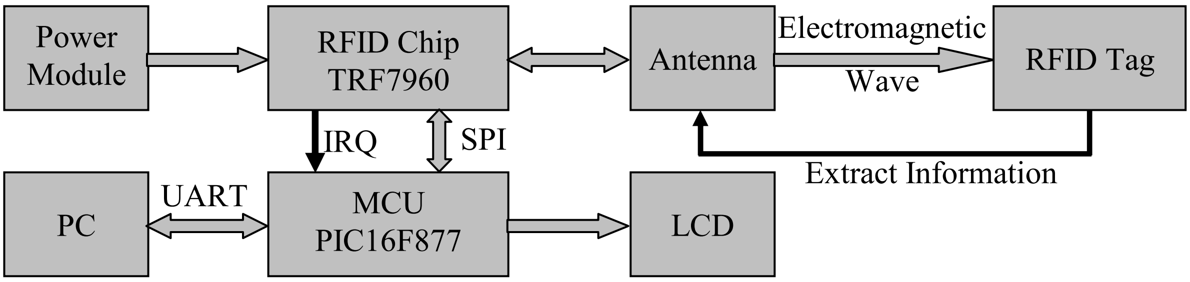

Fig. 2. Structure of the RFID reader

Realization of the protocol of ISO/IEC 15693 [5]

Format and Commands. The general format of ISO/IEC 15693 request is shown in Table 1, and the parts of SOF, CRC and EOF are generated automatically by TRF7960, the “Flags” is defined as Table 2 shown, the “CMD” is the commands, followed by “Parameters” [6] [7].

Table 1. General format of ISO15693 request

SOF	Flags	CMD	Parameters	CRC	EOF

Anti-collision Method. The reader sends a mask value and number of slots along with the inventory request. The VICC compares the least significant bits of its UID to the slot counter + mask value. If it matches, it sends a response. If only one VICC responds, then there is no collision and the reader receives the complete UID. If the reader detects a collision, it makes note of the slot number in which collision occurred. The reader sends an EOF to switch to the next slot. The VICC increments its slot counter on reception of EOF. This is repeated for all 16 slots. At the end of 16 slots, the slot pointer contents are examined. If it is not zero, it means that collision has occurred in one or more slots. A new mask value is calculated and the inventory request is sent with the new mask. This is repeated until there are no collisions. The anti-collision sequence is as follows [8] [9].

1) Check bit B5 of flag in the inventory request. If set, number of slots = 1; else number of slots = 16; If number of slots = 16, enable no response interrupt.

2) Initialize mask length, mask value and slot number pointer to zero.

3) Send inventory request with mask length and value.

4) Wait for end of transmit interrupt.

5) Wait for next interrupt. This can be due to: End of RX, Collision or No response.

6) Reset FIFO.

7) If number of slots is 16, transmit EOF. If number of slots is 1, exit.

8) Repeat steps 4 and 5 for all 16 slots. At the end of 16 slots, disable no response interrupt.

9) Examine slot number pointer. If not zero, increment mask length by 4 bits, calculate new mask: new mask = slot number (in which collision occurred) + old mask. If zero, exit.

10) Go to step 3 (new mask value and length). And decrement slot pointer by 1.

11) Go to step 9.

Table 2. ISO15693 protocol flags

bits	Inventory Flag(bit3)=0	Inventory Flag(bit3)=1
1	Sub-carrier (0=ASK, 1=FSK)	
2	Uplink Data Rate (0=Low,1=High)	
3	Inventory flag	
4	Protocol Extension (Always 0)	
5	Select Flag (0=If Address flag set-Use address mode, 1=Use Select Mode)	AFI Flag (0= Don't use AFI, 1= AFI)
6	Address Flag (0=Don't use address Mode, 1=Use address Mode)	No. of Slots Flag (0=16-slots, 1=1 slot)
7	Option Flag (0=Default value, 1=Must be set for Write operations)	Option Flag (0=Default value, 1=Must be set for Write operations)
8	RFU (Always 0)	RFU (Always 0)

Test and Conclusions

The application of this reader in the supermarket payment system, requires the ability to rewrite the price in the electronic tag of commodity and simultaneously read a number of commodity prices quickly. In this environment, range of the reader's magnetic field, rate of coincidence code of the commodity electronic label that R_c and commodity tag's moving speed are undoubtedly the key factors affecting the reader's performance. Assuming that the range of the reader's magnetic field is fixed, let commodities with the number of 300 to pass through the reader, with the following rules, the influences to reader's performance by rate of coincidence code that R_c and commodity tag's moving speed can be tested, and the result is shown in Fig. 3.

1) After detecting and dealing with a tag, should let the tag to stay in static state by sending the "Stay Quiet" command, for preventing the tag to be repeatable read in the reader's magnetic field.

2) As the tag can both be detected when into and out of the reader's magnetic field, therefore, according to the range of magnetic field, use a buffer to sequentially store tag's UID, the maximum number of the tags which can be stored is n (the value of n is related to the reader's magnetic field range), and the UIDs stored are not the same with each other. If the UID detected is identical with anyone in the buffer, don't any treatment with it, otherwise, do the operation of reading or writing, and store the new UID in the buffer.

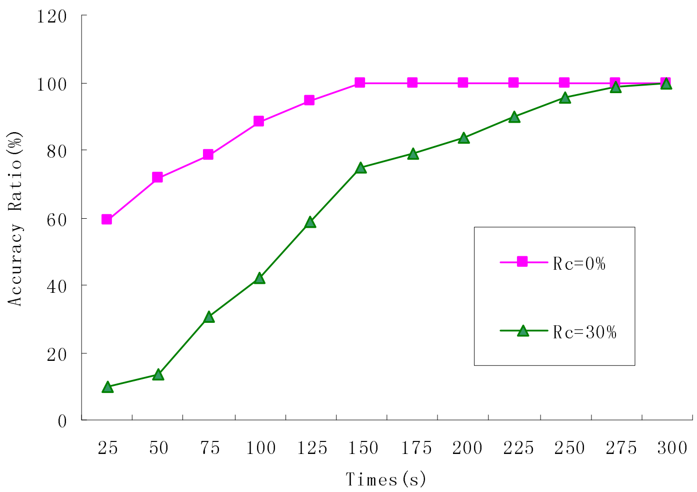

Fig 3. Influences by rate of coincidence code and tag's moving speed

The test result show: if the rate of coincidence code that R_c is zero in the 300 samples, when the passing time is about 150 seconds, the identification accuracy ratio is 100%. However, if the value of R_c is 30%, when the passing time is about 300 seconds, the identification accuracy ratio is 100%, and when the time is 150 seconds, the accuracy ratio is only 75%.

Acknowledgement

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