DESIGN AND IMPLEMENTATION OF RFID READER FOR ANIMAL TAGS

[1]HUSEYIN HARMANCI, [2]HAKAN ISIK

[1] Selcuk University, Faculty of Technical Education, Department of Electronic and Computer Education, Turkey
[2] Department of Electrical and Electronic Engineering, Selcuk University, Konya, Turkey
E-mail: [1]hharmanci@selcuk.edu.tr, [2]hisik@selcuk.edu.tr

Abstract- In this study, we designed of handheld RFID reader for ISO 11784 & 11785 standards that regulate the wireless communication protocol of animal identification with RFID technology. RFID ear tags are preferred by farmers in a lot of animal farms. Because they look the same as traditional ear tags, so farmers can use them in the same way. In the hardware side, the reader has a microcontroller and EM4095 that is a CMOS integrated transceiver circuit. We used it for reading 125 kHz RFID tags that have Manchester & bi-phase encoding ICs. The difference of this study is that we calculated the value of components for 134.2 kHz and developed new software for ISO 11784 & ISO 11785 code structure.

Key words- EM4095, ISO 11784 & ISO 11785 protocol, RFID Reader, 134.2 kHz Animal RFID.

I. INTRODUCTION

RFID tags have a storage capacity and they are able to transfer information without contact [1]. Low frequency passive RFID tags are usually used for logistics and traceability and usually have 125 kHz carrier frequency. RFID tags are useful for a lot of applications such as access control, animal identification and item tracking systems [2]. Some kinds of tags are the card, ear tag, glass and key chain. They also use Manchester or bi-phase encoding IC inside. This protocol contains 64 bits divided into five groups of information. First 9 bits are used for header and they are masked to “1”. Second 8 bits are located for customer ID. Other 32 bits have ID information. Last bit is “0” for the stop bit. Animal identification and traceability is constantly increasing because of RFID technologies made on standardization for advanced management of animal capital [3]. Inside the animal ear tags and implantable glass tags, there is a different carrier frequency and data protocol from other tags. The readers provide built-in support for animal identification according to ISO 11784 and ISO 11785 [2]. This protocol could be used for a traceability system for all farm animals according to The European Union. The International Organization of Standardization (ISO) published code structure of ISO 11784 at 1996. It has two RF protocols at 134.2 kHz carrier frequency. They are full duplex FDX or FDX-B and half duplex HDX. Tag and reader must be compatible to communication. If there is a power supply in the tag, it is classified as active tag. If it has not power supply, it is classified as passive tag. Passive tags are powered from reader by electrical or magnetic field coupling. It does not have its own power supply, so battery replacement problem does not occur [4]. We must design reader antenna unit to provide power transmission and wireless communication. Main task for the antenna design process is the calculation of appropriate L and C values for specific resonance frequency [5]. Microcontroller software takes different bits at capture time that is calculated for ISO 11784/5 protocol by software. If L and C values are not suitable, carrier frequency that is supposed to be 134.2 kHz can shift. So software cannot get header bits group and system cannot read animal RFID tags.
Another parameter that defines reading performance of passive RFID tags is the range of antenna and tag. This is the maximum distance that is enough for receiving power from reader antenna [6]. The reader that has strong magnetic field will transfer power to tag in maximum distance, and then tag sends modulated signals to reader. Reader detects signals and ID data are demodulated to microcontroller. If design is performed, the backscattered signal from the tag is demodulated by reader, without any hardware change [7].
In this study, we designed and developed a low cost RFID handheld reader to read the ID of the animal from RFID tags according to FDX-B animal identification protocol. We calculated appropriate L value of antenna and wrapped coil. Then we improved the software to detect demodulated signal from EM4095 IC. Thus, we changed capture timing according to 134.2 kHz. So we were able to make the RFID reader system compatible with a passive type of animal tags as distinct from standard 125 kHz RFID reader.

II. IMPLEMENTATION OF ANIMAL RFID TAG READER

1.1. Basic of RFID Reader

ID Number on traditional ear tags for animal identification is recorded for tracing data of animals’ activities. Disadvantages of traditional ear tags are inability to read because of deleted ink, reading wrong number and incomplete reading. RFID tag and electronic reader are used to avoid record missing or wrong data.

RFID systems consist of two parts. The first is transponder. Passive RFID animal tag consists of a coil and a processor into which is recorded identification information by manufacturer. As soon as the transmitter enters the magnetic field generated by the reader, voltage is induced on passive transponder's coil. Microprocessor in tag is activated by this voltage. The microprocessor that is in the animal RFID tag will modulate with 128 bits data signal and 134.2 kHz carrier frequency, and then it will transmit signals. If antenna coil has not the right L value, reader cannot capture formal data.

There are two types of protocol between the reader and transponder according to ISO 11784 standard. Protocol of half duplex supports two way data transfer but tag saves energy when it is powered and then it is expected to power off the electromagnetic field from reader, for sending data. Disadvantage of this protocol, reader waits while transponder is sending data.

Header includes 8 bits combination as 01111110. Then transponder sends data respectively: 1 bit of animal bit, 14 bits are reserved as 0, 1 bit of extra data, 10 bits of country code, 38 bits of ID code, 16 bits CCITT CRC code of previous 64 bits and finally 24 bits of application.

Table I. Protocol of FDX-B

MSB								LSB		
1	0	0	0	0	0	0	0	0	0	Header Bits
	1	1	1	1	0	0	0	0	0	
	1	0	0	0	0	1	1	0	0	
	1	0	1	1	1	1	0	0	0	38 bits ID code
	1	0	0	0	0	0	0	0	0	
	1	1	1	0	0	0	0	0	0	
	1	1	1	1	1	1	0	0	1	10 bits Country Code
	1	-	-	-	-	-	-	-	1	Extra Bit +14bits reserved
	1	1	-	-	-	-	-	-	-	Animal bit
	1	0	0	1	1	1	1	1	0	16 bits CCITT CRC
	1	0	0	1	1	1	1	1	0	
	1	0	1	1	0	0	1	1	0	24 bit Application Bits
	1	0	0	1	1	0	1	0	0	
	1	0	1	1	0	0	1	1	0	

Protocol of full duplex supports two way data transfer. Transponder can send data while electromagnetic field is power on. Header includes 11 bits combination as 00000000001. One bit is added after each 8 bits. Then the transponder sends data respectively 38 bits of ID code, 10 bits of country code, 1 bit of extra data, 14 bits are reserved as 0, 1 bit of animal bit, 16 bits CCITT CRC code of previous 64 bits and finally 24 bits of application. Data block is shown on Table I [8].

1.2. Design and Calculation of Hardware

EM4095 IC that has a direct antenna driver and can run at the range of 100-150 kHz carrier signal with few components was preferred in this design. This IC does not require external crystal oscillators, because it can generate carrier signal with internal oscillator. Also, it receives modulated data from antenna and sends demodulated data to microcontroller. RDY/CLK pin gives ready signal to microcontroller [9]. Parts of system are shown in Fig. 1: transmit coil, EM4095 for receiving modulated data and sending demodulated data to microcontroller, microcontroller for capturing data, LCD for showing ID numbers and USB data connection to PC for saving data.

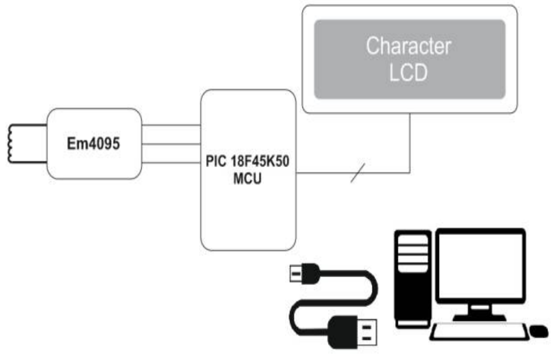

Fig. 1. Design of RFID reader hardware

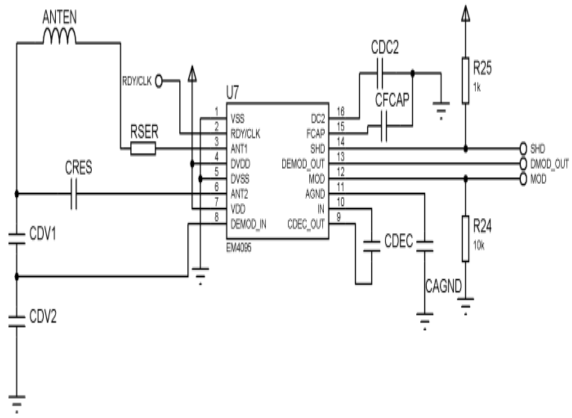

Fig. 2. Circuit of high Q factor of EM4095

EM4095 needs appropriate calculation of L and C value to generate 134.2 kHz carrier frequency. Antenna current must be below 250mA according to IC. High Q factor design of EM4095 connection is shown on Fig. 2.

The most important factor of antenna design is the calculation of inductor value. Our destination frequency is 134.2 kHz. Inductance of L was preferred 626uH. Inductor factor was preferred 40. Resistor value of antenna can be calculated with:

$$f_0 = 134.2kHz$$
$$L_A = 626uH \qquad Q_A = 40$$
$$R_{ANT} = \frac{2\pi f_0 L_A}{Q_A} = 13.15\Omega \qquad (1)$$

Equation (2) is the calculation of C_{RES} resonance capacitor.

$$C_{RES} = \frac{1}{(2\pi f_0)^2 L_A} = 2.2nF \qquad (2)$$

Antenna current and voltage is calculated when the system is powered on. R_{SER} was chosen as 27 Ohm in this design.

$$I_{ANT(peak)} = \frac{4}{\pi}\frac{V_{DD} - V_{SS}}{R_{ANT} + R_{SER} + 2R_{AD}} = 0.109A$$

$$V_{ANT(peak)} = \frac{I_{ANT(peak)}}{2\pi f_0 C_{RES}} = 115.2V \qquad (3)$$

Resonance frequency is calculated when C_{RES} = 2.2nF and C_{DV1} = 47pF and C_{DV2}=1.5nF are chosen.

$$C_0 = C_{RES} + \frac{C_{DV1}.C_{DV2}}{C_{DV1} + C_{DV2}} = 2.2nF$$

$$f_0 = \frac{1}{2\pi\sqrt{L_A.C_0}} \cong 134.2kHz \qquad (4)$$

In these calculations, we achieved appropriate L and C values for generating 134.2 kHz carrier frequency.

1.3. Improving Software for FDX-B Protocol

Demodulated data can be taken as 1 or 0 by hardware. We have benefited from the documents of EM Micro Company to design circuit. The most important factor of this system is synchronized capture time with 134.2 kHz carrier frequency. If time is not proper, data bits can overlap. Animal RFID readers get 128bits as distinct from standard 125 kHz RFID. CRC calculation of bits can give high accuracy. 16 bits CRC code is not used on reading algorithm of 125 kHz RFID tag.

We used CCS C compiler to software coding. Software has a two class for reading algorithm. EM4095 IC is initialized on the first algorithm. Capture and timer interrupts are initialized. And then software waits for the trigger of hardware interrupts. Data are stored in the temporary storage when interrupt is active. CCP1 register is used to capture time in between data rising and data falling. Pulse time is determined with difference of current time and before time. If this value is over threshold, bit is set 1. If not, bit is set 0.

The other algorithm is decoding ID numbers from raw data and comparing calculated CRC with taken CRC. We can see 38 bits data on LCD when reading is complete. Software steps are:

- Waiting to read “0” bit incessantly 10 times.
- Is 11. bit set to “1”? If OK, continue else return.
- Each 9 bits block is include 8 bit data and extra “1” at last. So we must decompose 8 bits block of raw data.
- Calculate CRC and compare with CRC of raw data.
- If the compared CRC values are equal, continue else return.
- Print 38 bits data as hex on LCD

III.RESULT AND CONCLUSIONS

In this study, we implemented a reader for animal traceable systems. The running system is shown on Fig. 3. When the reader closes to ear tag, the tag sends data to antenna. Then EM4095 demodulate signals to microcontroller. And then microcontroller sends ID numbers to LCD screen.

Ear tag number is 020100000016. It is a decimal number. Below is the binary equivalent:

000010010101110000011011010100100010000

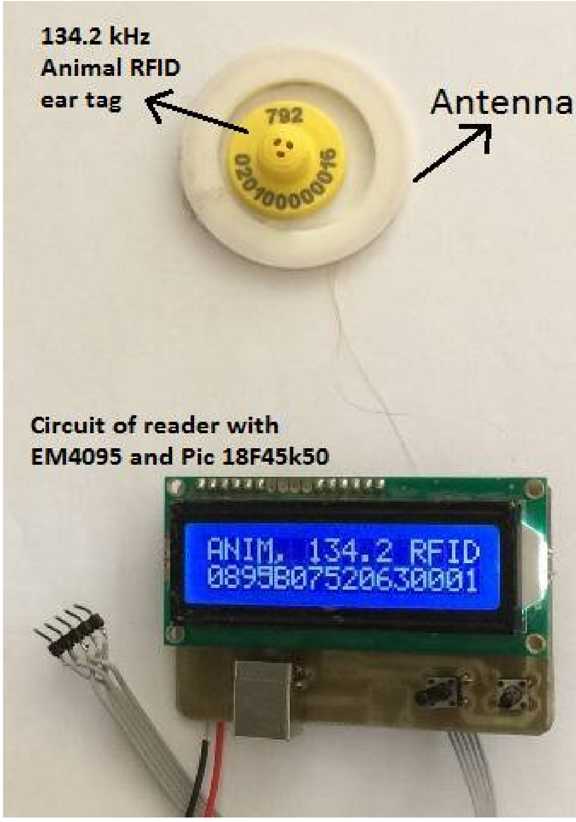

Fig. 3. Photo of animal RFID tag reader

Binary equivalent of data that are read begins with LSB bit as shown 0x08. First 38 bits of raw data are ID data. If LSB bit of 38bits ID data are adjusted to the right side, we can conclude that decimal ear tag number can be obtained. Next 10 data include binary equivalent of country code.

00001000	10010101	10110000	01110101
08	95	B0	75
00100000	01100011	00000000	00000001
20	63	00	01

In conclusion, performed system ensured the reading of identification definition with 100 percent accuracy. Thus, the data such as weight of animal, feed intake, milk yield and birth information is properly recorded. In a lot of animal farms, farmers need this information for quality cattle breeding. RFID animal ear tags and electronic reader gives an easy method to tracing animals' activities. Finally, we implemented the reader adapted with 134.2 kHz carrier signal and obtained correct results. The system could be improved by integrating with other systems that give animal weight or milk weight.

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