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On the Specifications and Designs of the Reader in a RFID System

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Abstract

Radio frequency identifications utilize the transmission of radio waves to reach the function of identification automatically; it is a kind of non-contact-type technology. By transmitting the signal from the reader, understanding the information from tags, and sending the information needed back to the reader, we can reach the purpose of distinguishing the object. And the reader will link with a host in order for various kinds of application. The RFID (radio frequency identification) system consists of mainly the following two parts: tag and reader. The tag is used for putting it on the object which wants to be distinguished, and it reads the information transmitting from the reader and sends back to the information that the reader needs. A reader is used for transmitting the message to the tags and receiving the information from the tags. Most readers include a interface (for instance: RS232, USB, WLAN, etc.) A reader with the interface can link to other systems to analysis the information received. The reader is besides responsible for communicating with tags and supporting the energy to the tags, it still need to bear the security of the information, reliability, and deal with the problems of collision.

Before we design and plan Reader-Tag transmission system, we should understand the various kind of parameters of the RFID system and the influence caused. So we will introduce the parameters and influence caused in this paper. And we can design these parameters of our whole project.

In RFID system, according to the information amount that can be carried on tags, tags are divided into two classes: 1-bit tags and n-bits tags (n>1). 1-bit tags are applied to EAS (electronic article surveillance). Its readers can only be used for detecting whether the tag is in the reading range or not, these two kinds of states. However, the n-bits tags can carry more information amount, so our plan will adopt the n-bits tags. There is a very important parameter in RFID system. It is the operating frequency. The higher the operating frequency is, the bigger the transmission range and the higher data rate. Our plan will adopt the 925MHz operating frequency to get the higher data rate.

Before data transferred between reader and tag, it should be matched optimally to the characteristics of the transmission channel. It is referred as coding in the baseband. Modulation is the process of altering the signal parameters of a high frequency carrier. As it will be shown, our plan will adopt pulse width modulation for data coding and ASK for modulation when data transferred from reader to tag. And our plan will adapt four interval bit cell encoding for data encoding and ASK for modulation.

Readers in all systems can be reduced to two fundamental functional blocks: the control system and the HF interface, consisting of a transmitter and receiver. The reader's HF interface can generate the high frequency transmission power to activate the tags and supply it with power. It also modulates the transmission signal to send data to the tag and receives and demodulates HF signals transmitted by the tag. [1]

In our project, the carrier frequency that we need is 925MHz. However, this high carrier frequency can not be generated directly by quartz crystal, so we must utilize the PLL synthesizer to generate the 925MHz carrier frequency that we want. Then, the carrier frequency is ASK-modulated by the modulator. In the receiving arm, the BPF can filter out the undesired band, and pass the signal band. Then, the signal band is translated to much lower frequencies. The translation is carried out by means of a mixer. This translation is called "downconversion mixing" or simply "downconversion." [2]

2. Specifications and characteristics of a RFID System

Before we design Reader-Tag transmission system, we should understand the various kinds of parameters of the RFID system and the influence caused. So we will introduce the parameters and influence caused in this section. And we can design these parameters of our whole project.

According for the power supply, we can divide the RFID system into two classes: the active RFID system and the passive RFID system. The active RFID system: tags have power supply itself, so it can offer the power to the microchip. The passive RFID system: tags do not have power supply, so the tags must be within the reading range of a reader. With the coupling component, the passive RFID system can get the power, time sequence, and information by the electric wave which is transmitting from the reader.

The selection of the active or passive RFID system will cause the following influence. It includes communication range, the collected information of many tags, inductor ability, and the information stored ability. The comparison between the active and passive RFID system is shown in Table 1. Though the active RFID system has many advantages, our project will adopt the passive RFID system because of its application consideration and less cost.

In RFID systems, according to the information amount that can be stored on tags, tags are divided into two classes: 1-bit tags and n-bits tags (n>1). 1-bit tags are applied to EAS (electronic article surveillance). Its readers can only be used for detecting and examining whether the tag is in the reading range or not, these two kinds of states. However, the n-bits tags can carry more information amount, so our plan will adopt the n-bits tags.

There is a very important parameter in RFID system. It is the operating frequency. The comparison between the low and high operating frequency is shown in Table 2. The higher the operating frequency, the bigger the transmission range and the higher data rate is. Our project will adopt the 925MHz operating frequency to get the higher data rate.

Before data transferred between reader and tag, it should be matched optimally to the characteristics of the transmission channel. This process involves providing the data with some degree of protection against the interference or collision and against intentional modification of certain signal characteristics. It is referred as coding in the baseband. Modulation is the process of altering the signal parameters of a high frequency carrier, i.e. its amplitude frequency or phase in relation to a modulated signal, the baseband signal. As it will be shown, our plan will adopt pulse width modulation for data coding and ASK for modulation when data transferred from reader to tag. And our plan will adapt four interval bit cell encoding for data encoding and ASK for modulation.

While the signal is transmitted, it will be corrupted unavoidably by noise, causing the incorrectness of the signal. In order to detect whether the information is correct or not, we need to make use of technology of a certain checksum to detect and examine the wrong signal. Several kinds of checksum procedures are as follows: parity checking, longitudinal redundancy check (LRC), cyclic redundancy check (CRC). Our plan will adopt the CRC procedure.

The operation of RFID systems often involves a situation in which numerous tags are present in the interrogation zone of a single reader at the same time. In such a system, when tags pass the signal back the reader, it will cause the mutual interference between each other, making the reader unable to get the correct signal. This is so-called collision problem. There are several multi-accesses that can solve the problem, including FDMA, TDMA, CDMA, SDMA.

RFID systems are increasingly being used in high security applications, such as access systems and systems for making payments. However, the use of RFID systems in these applications necessitates the use of security measures to protect against attempted attacks. In order for system security, there are three kinds of protocol to protect the system, including mutual symmetrical authentication, authentication using derived keys, encrypted data transfer.

Table 1. active RFID system and passive RFID system

	Active RFID system	Passive RFID system
Power supply	Built inside (battery)	none
Acquisition of the tag power	Continued	Get only in the interrogation range of a reader
Memory type	Readable and writable	Read only
Memory capacity	Relatively large	Relatively small
Distance of induction	Relatively far	Relatively short
Size、weight	Relatively large and heavy	Relatively small light
Service life	yes	no
Equipment	large	small
Price	relatively high	Relatively low
The signal strength from reader to tag	Relatively low	Relatively high
The signal strength from tag to reader	Relatively high	Relatively low

Table 2. the characteristic of the low and high operating frequency of a RFID system

	Low frequency	High frequency
Transmission range	Relatively short	Relatively long
Data rate	Relatively low	Relatively high
Price	Relatively cheap	Relatively expensive
The tag must be within the line of sight	Don't need	The higher frequency the need
Power	Relatively low	Relatively high
The ability to go through the nonmetal material	Relatively strong	Relatively weak
Antenna length	Relatively long	Relatively short

3. Structure of a Reader

A RFID reader can be reduced to two fundamental functional blocks: the control system and the HF interface, as shown in figure 2. The HF interface consists of a transmitter and receiver. The control system comprises an ASIC module and microcontroller. In order that it can be integrated into a software application, this reader has an RS232 interface to perform the data exchange between the reader and the external application software.

The reader's HF interface can generate the high frequency transmission power to activate the tags and supply it with power. It also modulates the transmission signal to send data to the tag and receives and demodulates HF signals transmitted by the tag.

In our project, the carrier frequency that we need is 925MHz. However, this high carrier frequency can not be generated directly by quartz crystal, so we must utilize the PLL synthesizer to generate the 925MHz carrier frequency that we want. Therefore, we design the quartz oscillator which can generate the 37MHz reference frequency in the transmission arm. The reason for using quartz oscillator is that it has good phase noise. Then, the transmitter's carrier frequency is determined by the reference frequency. The PLL synthesizer ensures that each RF value, ranging from 922MHz to 928MHz, can be achieved by using a crystal with a reference frequency according to: fref=fc/N, where N=25 is the PLL feedback divider ratio. Then, the carrier frequency is ASK-modulated by the modulator.

In the receiving arm, the BPF can filter out the undesired band, and pass the signal band. Then, the signal band is translated to much lower frequencies so as to relax the Q required of the channel-select filter. The translation is carried out by means of a mixer. This translation is called "downconversion mixing" or simply "downconversion."

In the following paragraphs, we will introduce briefly some basic circuits in the HF interface.

(1) Quarz oscillator
In the transmission arm, we use quarz oscillator to generate a stable reference frequency. The advantage for using quarz oscillator is that it has good phase noise. An oscillator is mainly comprised of two parts. One is resonator and the other is active device (MOS transistor), as shown in Fig. 3. In Fig. 3, we use the equavlent circuit of quarz crystal and Cgd, Cgs, Cds are parascitic capacitance of the MOS.

(2) Frequency synthesizer
The frequency synthesizer can generate the carrier frequency of 925MHz. Fig. 4 is the basic block diagram of the PLL synthesizer. The PD is a phase

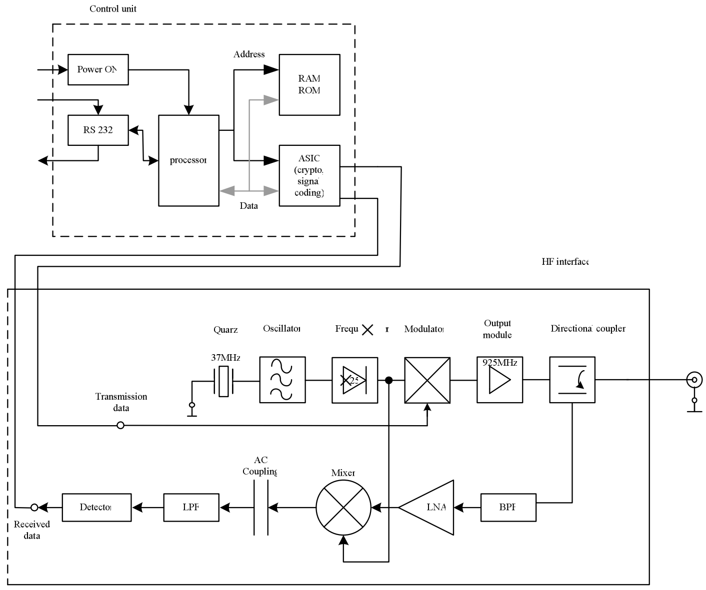

Figure 2.block diagram of a RFID reader

detector, LPF is the low pass filter, VCO is the voltage-controlled oscillator. The PLL operates as follows. The phase detector produces an output whose dc value is proportional to the phase difference between the two inputs of the phase detector. The low-pass filter suppresses high frequency components in the PD output, allowing the dc value to control the VCO frequency. The VCO then oscillators at a frequency equal to the input frequency multiplied a number. Thus, the LPF generates the proper control voltage for the VCO.

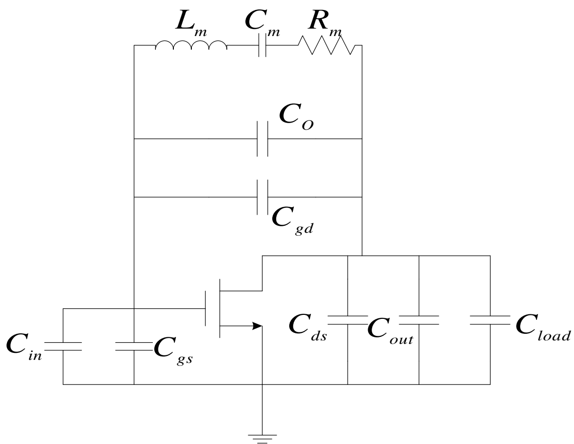

Figure 3.The circuit of quarz oscillator

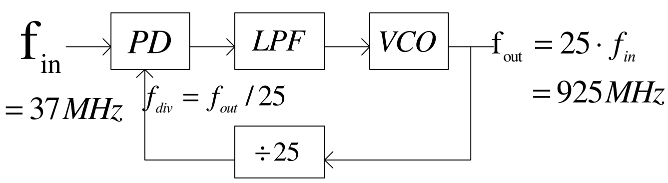

Figure 4.Block diagram of the frequency synthesizer

(3) Power amplifier

The major function of the power amplifier is to increase the power of transmission signal. Then the transmission signal has the enough energy to activate the tag. Fig. 5 is a class E power amplifier.

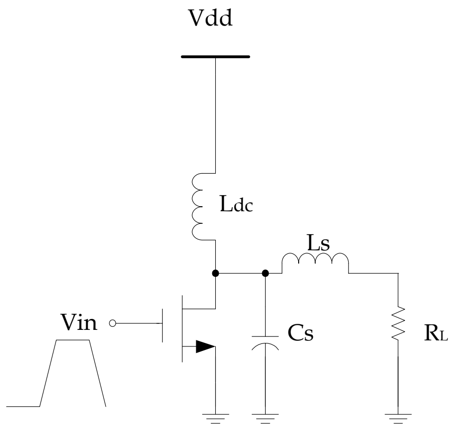

Figure 5. the circuit of a class E power amplifier

(4) Directional coupler

A direction coupler separates the system's own transmission signal from the weak backscatter signal of the tag. A directional coupler consists of two continuously coupled homogeneous wires, as shown in figure 6. If all four ports are matched and power P1 is supplied to port 1, then the power is divided between ports 2 and 3, with no power occurring at the decoupled port 4. The same applies if power is supplied to power 3, in which case the power is divided between ports 1 and 4.

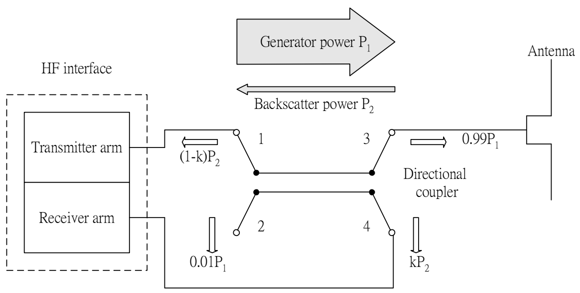

Figure 6. Layout and operating principle of a direction coupler for a backscatter RFID system

(5) Low-noise amplifier (LNA)

After filtering out the frequency band 922~928MHz by band-pass filter, the receiving signal need to be amplified by a LNA to resist the inference of noise of the following several stages of circuits. Because the LNA must input a large signal without being distorted, it must have a good linearity. The LNA is designed to have a 50-Ω resistive input impedance. This is because the band-pass filter following the antenna is usually designed to be used in various transceiver systems and must therefore operate with a standard termination impedance, typically 50Ω. The LNA circuit is shown in figure 7.

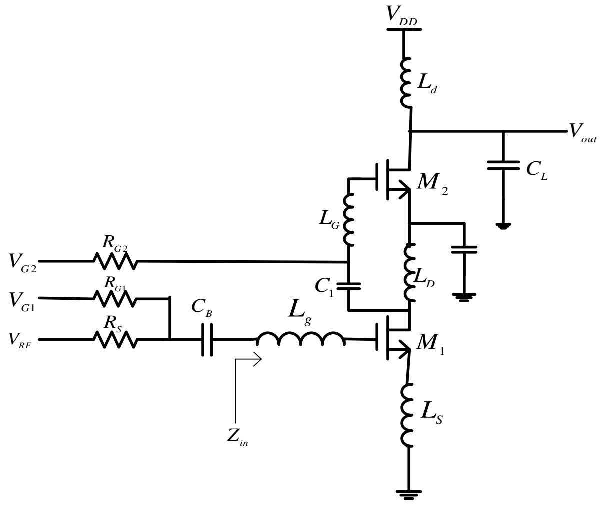

Figure 7. the LNA circuit

(6) Mixer

A mixer can downconvert the RF signal to the baseband. The mixer circuit is shown in figure 8.

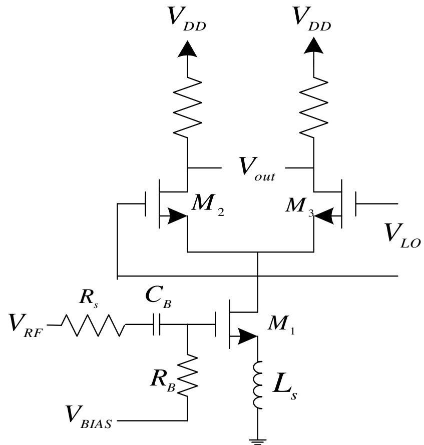

Figure 8. the mixer circuit

Besides communicate with tags, readers also can communicate with the host computer through the internet. The communication between software application and reader or tag and reader must follow the principle of master-slave principle. This means that all reader and tag activities are initiated by the application software. A simple read command from the application software to the reader can initiate a series of communication steps between the reader and a tag. A read command first leads to the activation of a tag, followed by the execution of the authentication sequence and finally the transmission of the requested data.

4. Protocol

In this project, we plan to operate the RFID system under the frequency of UHF. In order to confirm the parameters of the RFID system, we must understand the current standard protocol in the UHF. And we choose a kind of standard to come as our reference to determine the parameters of the RFID system. Then we could realize further our RFID system. In the following we divide this section into two parts. The first part describes the standard protocol in the UHF. The second part describes the specifications and parameters of our RFID system which we define.

We will consult the protocol of Auto-ID class 1 to define the specifications of our RFID system, listing as follows:

(1) Adopting the passive RFID system: the tag itself has no power supply.
(2) Adopting the half-duplex (HDX) and electromagnetic backscatter coupling.
(3) Operating frequency: we choose the UHF band 922~928 MHz.
(4) According for the direction of transmission, data rate, data encoding and modulation are different.
   (i). Downlink (data transmission from reader to tag)
   Data rate: 70.18kb/s
   Data encoding: PWM (pulse width modulation), as Fig. 1 shows, T0 is 14.25us.
   Modulation: 100%ASK

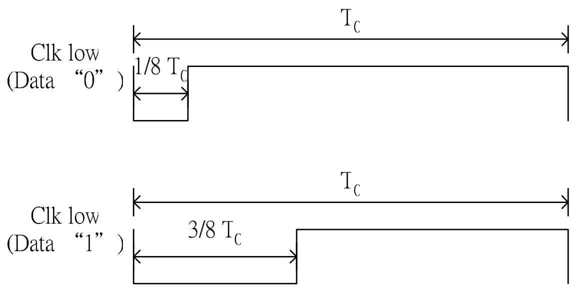

Figure 9. PWM timing for binary zero and binary one

   (ii) Uplink (data transmission from tag to reader)
   Data rate: 140.35kb/s
   Data encoding: four interval bit cell encoding, as shown in figure 10, T0 is 14.25us, so one bit cell is 7.13us.
   Modulation: ASK.
(5) In order to keep data transmitting correct, we adopted the 16-bit CRC-CCITT.
(6) Data structure: According to the protocol of Auto-ID class 1, the data of tag will store in the Identifier Tag Memory (ITM) which includes one EPC (Electronic Product Codes) code, 16-bit CRC and 8-bit passwords, as shown in figure 11.

In the Electronic Product Codes there are four fields, which are, in order: a version number, defining the variety of EPC among a number of possible structures; a domain manager number which is effectively a manufacturer number; an object class which is equivalent to a product number; and a serial number, as shown in figure 12.

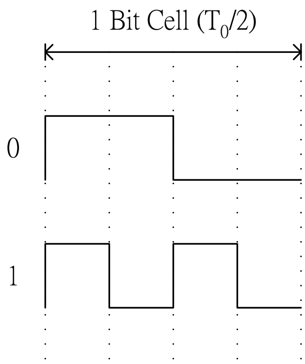

Figure 10.bit cell encoding (tag-to-reader)

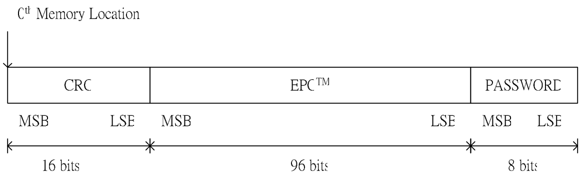

Figure 11. Identifier tag memory

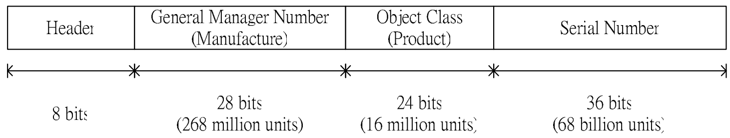

Figure 12. EPC-96 codes

In this paragraph, we will describe the communication interface of reader-to-tag. The interface we describe is looked up from the Auto-ID class 1, which defines the commands that are transmitted from reader to tags and the response of tags. A complete command from a reader consists of eight fields and five parity bits over those fields. The fields and parity bits have the following format:

[PREAMBL] [CLKSYNC] [SOF] [CMD] [P_1] [PTR] [P_2] [LEN] [P_3] [VALUE] [P_4] [P_5] [EOF]

The commands that a reader may send to a tag are divided into required commands and identifier programming commands. A tag must implement a required command. A tag will implement identifier programming commands depending upon the type of ITM memory implemented on the tag.

Table 3.Read-to-Tag commands

COMMAND NAME	COMMAND CODE (MSB…LSB)	TAG REPLAY
Required commands		
ScrollAllID	0011 0100	ScrollID **Reply**
ScrollID	0000 0001	ScrollID

		Reply
PingID	0000 1000	PingID **Reply**
Quiet	0000 0010	**None**
Talk	0001 0000	**None**
Kill	0000 0100	**None**
Identifier programming commands		
ProgramID	0011 0001	**None**
VerifyID	0011 1000	VerifyID **Reply**
LockID	0011 0001	**None**
EraseID	0011 0010	**None**

A class 1 compliant tag will change his internal state or perform backscatter modulation in response to commands defined above only. A class 1 compliant tag will interpret all commands codes not defined herein as unknown commands and will neither change its internal state nor perform backscatter modulation in response to any such unknown command.

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