A survey of RFID reader leading to FPGA based RFID system

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ABSTRACT

The world has become wireless now a days and one of the hottest topic in wireless technologies is Radio Frequency Identification (RFID). As s research scholar I have undertaken literature survey comprising of in-depth study of RFID, as part of my ongoing research, here by I share my key findings during my survey in this paper. The key aspects explained are RFID definitions, basic system, design, classification, communication mechanism application, challenges, future trends etc.

Keywords

Radio Frequency Identification (RFID) technology, Types of RFID, Field coupling in RFID, RFID tags, Applications of RFID, RFID reader, FPGA based RFID reader.

1. Introduction

In the last years, the telecommunications and generally the wireless networks have revolutionized the way people communicate, and for the first time it gives the customers the feeling of being virtually connected. It is this closeness or convenience that has made current wireless networks so successful.

Radio-frequency identification (RFID) is an automatic identification method, relying on storing and remotely retrieving data using devices called RFID tags. RFID technologies have been in existence since World War II. Radio frequency reader will read information from device called tag or transponder (transmitter and responder). These Radio frequency waves are electromagnetic waves having a wavelength varying from 0.1 cm to 1000 km. Radio frequency have a frequency value between 30 Hz to 300 GHz. Electromagnet waves can be infrared, visible light waves, ultraviolet, gamma rays, X-rays and cosmic rays etc. RFID uses radio waves with a frequency of 30 KHz to 5.8 GHz.

RFID can be defined as

"It is the wireless non-contact use of radio-frequency electromagnetic fields to transfer data, for the purposes of automatically identifying and tracking tags attached to objects."[1]

RFID tags can be categorized as

- Passive
- Semi-passive
- active

Based on power source.[1][2]

1.1 Passive tags of RFID

Passive tags are battery less, so to acquire power they use signals carried by RFID reader. These tags are powered by the reader antenna through an antenna located on the tag. The power which is used by IC to transmit a signal back to reader or reflect back a modulated, encoded identification is produced by coupling the readers' transmission and specially designed antenna, which in term produces small voltage potential by induction or E-field capacitance.

1.2 Semi-passive tag of RFID

Semi-passive tag of RFID runs the microchip circuitry by an on-board power source (such as battery). These tags however utilize a power source but also still operates using backscatter techniques. The semi-passive tags were studied and estimated using graphical methods. This study will provide closed-form as calculation, while we study both passive and semi-passive tags in more generalized context. The main approach of us provides tag load selection constraints and rules without restricting discussion to specific tag/reader circuitry or minimum scattering antennas.

1.3 Active tags of RFID

These tags incorporate battery for signal transmission to a reader antenna. Active tags perform two functions i.e. either emit a signal at a predefined interval or transmit only when addressed by a reader. The power for the RF transmission is provided by the battery only, not by an induction or capacitive coupling. It has got with the built-in battery which helps to operate at a greater distance and at higher data rates for a limited life, driven by the longevity of the built-in battery, and

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higher costs. If the plans of implementing at lower costs, passive tags are more attractive solutions.

1.4 RFID System

The figure 1 shows typical RFID system. In every RFID system the transponder Tags contain information. This information can be as little as a single binary bit, or be a large array of bits representing such things as an identity code, personal medical information, or literally any type of information that can be stored in digital binary format.

RFID transceiver communicates with a passive Tag. Passive tags have no power source of their own and instead derive power from the incident electromagnetic field. Commonly the heart of each tag is a microchip. When the Tag enters the generated RF field it is able to draw enough power from the field to access its internal memory and transmit its stored information. When the transponder Tag draws power in this way the resultant interaction of the RF fields causes the voltage at the transceiver antenna to drop in value. This effect is utilized by the Tag to communicate its information to the reader. The Tag is able to control the amount of power drawn from the field and by doing so it can modulate the voltage [3]

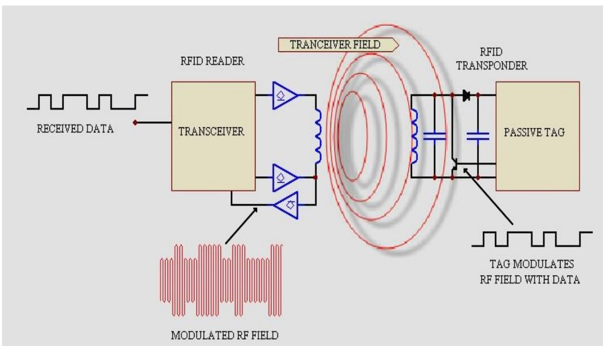

Fig.1 RFID system

sensed at the Transceiver according to the bit pattern it wishes to transmit.

The figure 2 shows the communication between transponder (tag), RFID reader and host system. The RFID reader sends energy to tag for power (passive tag), tag sends data back to the reader. The received data is decoded by reader and sends to the host system for processing. The communication space between reader antenna and tag is called as interrogation zone where data clock and energy are exchanged.

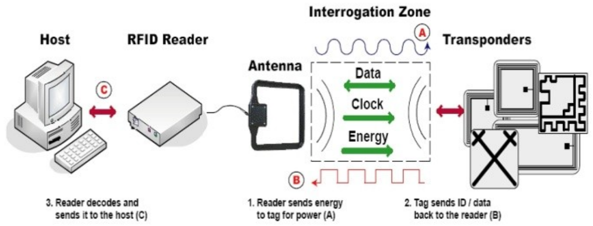

Fig.2 RFID communication

1.5 Regulations and Standards for RFID

- Data transmission rates
- Reflections and interference
- Eddy current losses
- Absorption by non-conductors

1.6 Tag Architecture of RFID

The figure 3 show tag architecture of RFID. As the RFID tag is a passive system, a DC voltage must be generated to bias the circuits of the tag. The rectifier is the main block in the RFID tag as it provides the needed DC voltage to the other blocks of the system. The DC voltage is generated by converting the received RF signal into a DC power. The demodulator is responsible for detecting the data sent by the reader to the tag. In this system, the reader sends the data as short gaps in the RF signal. So a simple envelope detector is used to detect these gaps. The modulator is simply a switch that either shorts the input impedance of the chip, or leaves it matched with the antenna. The switch is implemented as a single NMOS transistor. The digital control block is responsible for generating all the control signals needed in the RFID tag system. The design of the digital control, it is divided to two sub-blocks

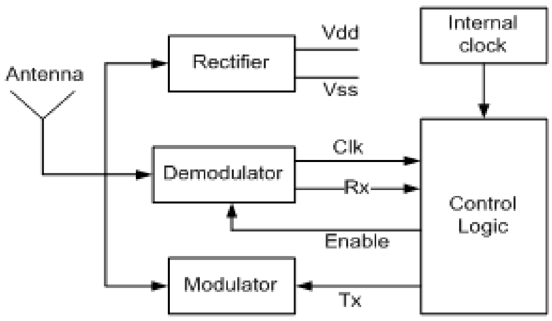

Fig.3 Tag architecture

	LF	HF	UHF	Microwave

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Freq. Range	125-134Khz	13.56Mhz	866-915Mhz	2.45-5.8Ghz
Read Range	10cm	1 meter	2-7 meter	1 meter
Market share	74%	17%	6%	3%
Coupling	Magnetic	Magnetic	Electro magnetic	Electro magnetic
Existing standards	11784/75, 14223	1800-3.1, 15693, 14443A,B and C	EPC C0, C1, C1g2, 18000-6	18000-4
Applications	Smart card, Ticketing, Animal tagging, Access Laundry	Small item management, supply chain, anti-theft, library, transportation	Transportation vehicle ID, Access, Large item management, supply chain	Transportation vehicle ID, Access/security , Large item management, supply chain

Table.1 RFID tag details

- Mode selector: This sub-block is responsible for determining the mode of operation of the RFID tag.
- Backscattering control: This sub-block is responsible for controlling the period at which the backscattering is active.

1.7 Communication mechanism in RFID

To avoid complicated synchronization circuits, the reader fully controls the communication between the reader and the tag, i.e. the RFID tag cannot send data unless triggered by the RFID reader. The communication between the RFID reader and the RFID tag can be divided according to communication direction into two links:

1.7.1 Forward link

This is the communication link from the RFID reader to the RFID tag. In power-up mode, a continuous RF wave is transmitted from the RFID reader to the RFID tag, which is used to power the tag. After entering the addressing mode, the data is sent from the RFID reader to the RFID tag as short gaps in this continuous wave.

1.7.2 Reverse link

This is the communication link from the RFID tag to the RFID reader. This link is active only in reading mode, where the RFID tag needs to send its data to the RFID reader. The communication in the reverse link is achieved using backscattering. The reflected wave should be detected by the RFID reader.

1.7.3 Backscattering in RFID

The communication between a tag and a reader is achieved by two basic methods, namely, inductive or near-field coupling and backscatter or far field coupling. When the tag is located at a very close distance from the base station antenna, the data exchange from the tag to the antenna occurs due to the voltage induced in the tag coil through the antenna coil. This system behaves like a transformer type coupling, wherein the reader. antenna acts as a primary coil and the tag coil as a secondary coil of the transformer.

Using backscatter technology, interference from nearby transmitters can be avoided, since the reader controls the frequency of operation and can shift it if nearby transmitters are operating at the same frequency. Also, the reflected signal strength from the tag is proportional to the incident interrogator signal, so tags outside the incident beam focus area will reflect a weaker signal that the reader antenna can reject.

2. Field coupling in RFID

2.1 Near field coupling in RFID

In near-field region the electromagnetic (EM) field is reactive in nature-the magnetic and electric field are perpendicular and

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quasi-static. Based on the type of antenna, one field (such as the electric field for a dipole or magnetic field for a coil) dominates the other. Most near-field tags rely on the magnetic field through inductive coupling to the coil in the tag. This mechanism is basically due to Faraday's principle of magnetic induction. The magnetic field is produced around the coil of a reader due to current flow in the coil. The magnetic field produced causes the generation of the small current in a tag's coil.

The communication between the reader and tag is through a load modulation mechanism. If the any variation of the current flowing through a tag's coil appears it varies the reader's coil current also, mainly due to mutual induction. This variation is detected by reader. A tag varies the current by changing the load on its antenna coil, and hence the mechanism is called load modulation.

The boundary between near-field and far-field regions is inversely proportional to frequency and approximately equal to c/2pf, where c is the speed of light. Therefore, only low carrier frequencies are used in near-field coupling tags; the two most common are 128 kHz (LF) and 13.56 MHz (HF).

For example, the boundary distances are 372 m for 128 kHz and 3.5 m for 13.56 Mhz. One problem with use of low frequencies is that a large antenna coil is required. Also, the power of magnetic field of a magnetic dipole loop drops as1/r6 in the near-field region, where r is the distance between areader and a tag. Another downside is the low bandwidth and, hence, the low data rate.

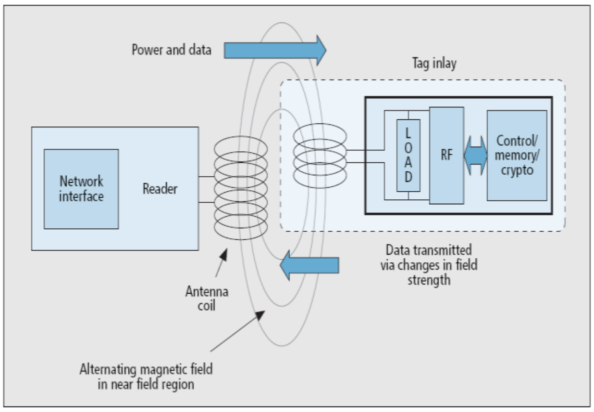

Fig.4 Near field communication using inductive coupling

2.2 Far field coupling in RFID

Electromagnetic (EM) field in the far-field region is radioactive in nature. Coupling here captures EM energy at a tag's antenna as a potential difference. The energy incident on the tag's antenna is getting reflected back as a part. This is due to impedance mismatch between the antenna and the load circuit. Changing the mismatch or loading on the antenna can vary the amount of reflected energy; this technique is called as backscattering.

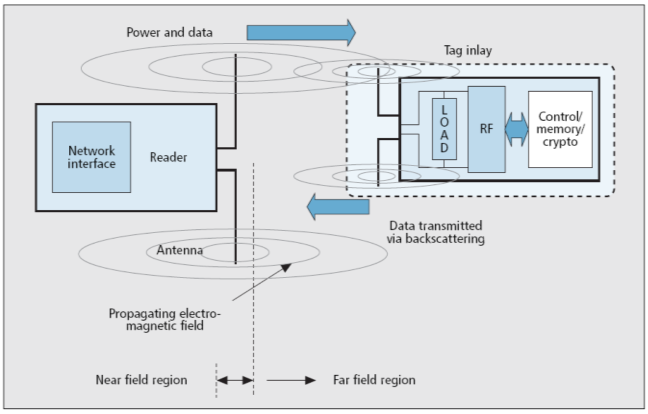

Fig.5 Far field communication via backscattering

These Far-field coupling is commonly employed for long-range (5–20 m) RFID, and, in contrast to near-field, there is no restriction on the field boundary for far-field RFID. In far field region the attenuation of the electromagnetic field (EM) is proportional to 1/r2, which is smaller by orders of magnitude than in the near-field range (which is 1/r6). The far-field tag operates at high frequencies; hence the antenna size can be small, leading to low fabrication and assembly costs. The far-field passive tags consume only a few microwatts (practical), this is due to innovation in the circuit designs combined with advances in silicon technology.

These tags usually operate it the 860-960 MHz UHF (ultra high frequency) band or in 2.45 GHz Microwave band. The table shows RFID tag detail based on frequency. Various form factors and antenna shapes are used for far-field tags to meet application requirements.

The several emerging technologies in the UHF and LF bands try to exploit advantages of both near-field and far-field tags. UHF proponents are promoting near-field UHF tags for label tagging, which has been the sole domain of HF near-field tags. The main purpose of using the UHF here is the tag cost is low and reduced antenna size. The new active RFID technology called Rube which operates in LF band and employs long-wave magnetic signaling. It can achieve a read range of 30 m. Long-wave magnetic signaling has a great advantage: It is highly resistant to performance degradation

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near metal objects and water, a serious problem for UHF and Microwave far-field RFID.

3. Applications of RFID

1. Access control
2. Anti counterfeiting
3. Asset management and asset tracking
4. Fine art tracking
5. Document tracking
6. IT asset management or Information technology asset tracking
7. Animal tracking
8. RFID in construction: Tool tracking, Pipe tracking
9. Apparel tracking (RFID in clothes)
10. Food safety and traceability
11. RFID in Hospital and health care
12. RFID in passport
13. RFID payment system
14. Personal identification and people tracking
15. Conference and trade shows
16. Time and Attendance
17. Pharmaceutical tracking and traceability
18. Race timing (Running bicycles, vehicle)
19. RFID mining
20. RFID supply chain or RFID in logistics
21. Cargo container tracking
22. Work in progress management
23. Vehicle identification and access
24. Toll payment systems

4. Proposed RFID System Using FPGA

The fig 6 shows typical RFID based system, the RFID reader is connected to workstation via network. The proposed RFID system using FPGA is as show in fig.7 when the RFID tag is bought near to the RFID reader mutual inductance would occur between RFID tag coil and RFID reader because reader as power supply and its coil will generate electromagnetic

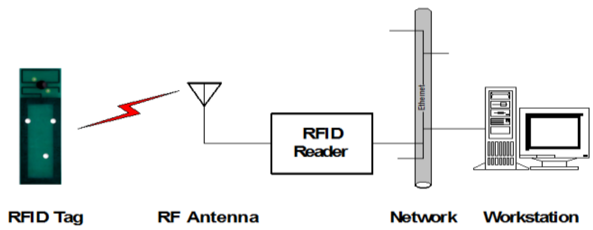

Fig. 6 RFID based system

field which will cut when RFID tag would enter in this field. Each RFID tag would be differentiated depending on the number of turns of their coil. After the identity of each coil is detected depending upon the voltage generated by mutual

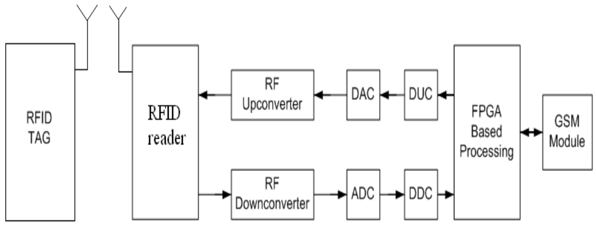

Fig.7 Proposed RFID System using FPGA

Inductance, this voltage is given to Analog to Digital converter which will convert this analog signal into digital bits and then it will be down converted and given to FPGA which will process and authenticate the RFID tag different type of encryption can be done on the digital signal to add security to the data.

5. Advantages of using FPGA

- Low cost rapid prototype hardware platform.
- Complete support for hardware modeling (behavioral simulation and RTL synthesis).
- Shortened development time.
- Reprogram ability and Low NRE cost.
- Programmability and scalability and flexibility.
- Field up gradation.
- High density, high speed, low power.
- Shortened time of design changes.

6. Future trends in RFID technology

Future Innovation within RFID Technology will be seen in:

1. Real Time Location Systems (RTLS)
2. RFID sensor systems
3. Smart Active Labels (SALs)
4. Sophisticated multi-functional devices
5. More NFC and mobile phones using RFIF applications
6. USB technology - transforming devices into RFID equipment
7. Adopted e-Ticketing and e-payment schemes New and developed Identification methods, ideas, systems and applications - with and in competition with RFID.
8. Standardization, EU cross performance and cross over areas.

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9. More SMART IoT (Internet of Things) Buildings, Zones, Cities etc.

7. CONCLUSIONS

Keeping in mind the key facts and findings of my in-depth literature survey, summarizing all the below mentioned reference documents. I have proposed a Novel architecture for FPGA based RFID system with GSM interface for long range application. I also plan and propose evaluated active and passive tags along with other long range wireless interfaces for various applications with an emphasis on security and low power.

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