Comparison of RFID Systems from Aspect of the Operating Frequencies and One Practical Implementation

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Abstract – **In this paper the description of RFID systems and their comparison from aspect of the operating frequencies are presented. There are several different operating frequency bands which affects cost, size, reading range and performance of RFID systems. An overview of these characteristics and one concrete realization of RFID system for access control are given, too.**

Keywords – **RFID Systems, Operating Frequencies, Access Control.**

I. Introduction

RFID (Radio Frequency Identification) is a technology that uses communication via radio waves to exchange data for purpose of identification, tracking and many other applications. An RFID system is always made up of minimum two components, which are represented in Fig. 1, and that are:

- the transponder or tag, that carries information;
- and the interogator or reader, which, depending on design and technology used may be read or read/write device.

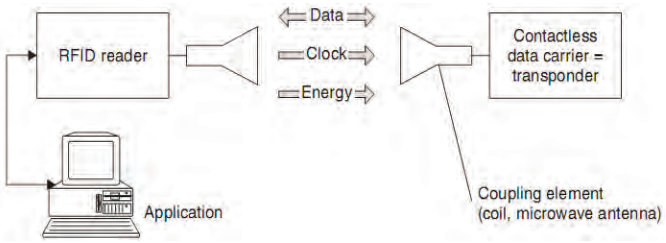

Fig. 1. The reader and transponder are the main components of every RFID system

RFID systems exist in countless variants, produced by an almost equaly high number of manufacturers. If we want to maintain an overview of RFID systems we must seek out features that can be used to differentiate one RFID system from another. In Fig. 2 features which can be used for comparing RFID system are given. One of the most important features of RFID systems is the operating frequency range of the system. Accordingly, in this paper attention to comparison of RFID systems depending on operating frequency ranges is devoted. After that, one practical realization of RFID system for access control is given.

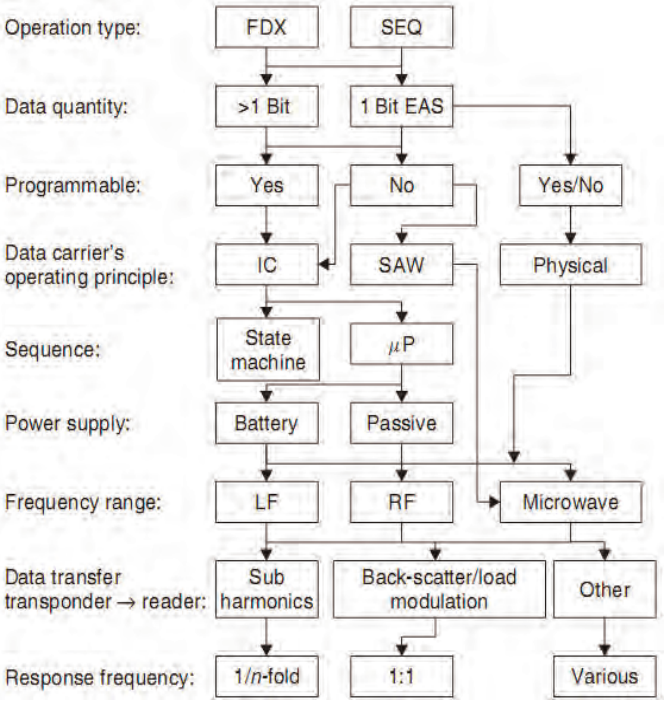

Fig. 2. The various features of RFID systems

II. Operating Frequency Ranges of RFID Systems

The frequency of an RFID system defines the relationship between the tag and the reader, and impacts on many other characteristics of RFID system like reading range, data transmission speed, cost, size and others. In accordance with the previous, there is differences in the typical uses of RFID systems some of which are access control and security, logistics, animal ID and tracking, electronic article surveillance, moving vehicle toll and many others.

There is no global public body that governs the frequencies used for RFID. In principle, every country can set its own rules for this. Because of that, today we have RFID systems which operates at widely different frequencies. But, these various operating frequencies are generally considered to be organized into four main frequency bands which are commonly used:

- 125 – 134kHz low frequency band (LF);
- 13.56MHz high frequency band (HF);

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- 860 – 960MHz ultrahigh frequency band (UHF);
- 2.45GHz – 5.8GHz microwave band.

III. Comparison of RFID Systems Depending on Operating Frequency Ranges

Before we make comparison of RFID systems depending on operating frequency ranges it is important to notice that there are difference in energy supply of transponders. Here we distinguish between passive, active and semi-passive transponders. This also affects size, cost, lifetime and reading range of transponder. Passive transponders do not have any power supply. All the energy required for operating the transponder is provided by magnetic or electromagnetic field produced by the reader and because of that their lifetime is not limited. In contrary, active transponders have their own energy supply, usually in form of a battery and their lifetime is limited to a maximum of 10 years. Semi-passive transponders also use battery to power the digital logic on the chip, but still use harvested power for communication, and have limited lifetime, too. Actual cost of passive tags start at $0.05 each and for special tags go to $5, that also depending on operating frequency, in the contrary to the cost of active tags which can go up to $100.

Further, more attention will be devoted to RFID systems that using passive transponders because of their characteristics and ease of use.

A. Low frequency band

Low frequency RFID systems are typically 125 KHz, though there are systems operating at 134 KHz as well. This frequency band provides a shorter read range, less than 0.5m for passive transponders, and slower read speed than the higher frequencies. This speed is typically less than 1kbps. Low frequency RFID systems have the strongest ability to read tags on objects with high water or metal content compared to any of the higher frequencies. They are suitable for working around corners and signal carried by this low frequency can pass through most objects. They are more tolerant of reflections and radiations. Low frequency tags are slightly more expensive than higher frequency tags.

The first RFID systems were implemented in this low frequency range. Typical low frequency RFID applications are access control, animal tracking, vehicle immobilizers, healthcare applications, product authentication and various point-of-sale applications.

B. High frequency band

High frequency RFID systems operate at 13.56 MHz, and have a feature of a greater read range and higher read speed than low frequency systems. Read speed or data transfer rate goes to approximately 25kbps. Also, the price of the tags is among the lowest of all RFID tags. Typical read range is up to 1.5 meters for passive transponders, and the ability to read tags on objects with high water or metal content is not as good as low frequency systems but stronger than ultrahigh frequency systems.

Applications include smart cards and smart shelves for item level tracking, and are also currently used to track library books, healthcare patients, product authentication and airline baggage. Another common application is maintenance data logging for sensitive equipment that needs regular checking such as fire suppression systems.

C. Ultrahigh frequency band

Ultrahigh frequency RFID utilizes the 860 to 960MHz band typically 868 MHz in Europe and 915 MHz in North America. Ultrahigh frequency tags typically cost about the same as high frequency tags. Read range is up to 8 meters with passive transponders and the data transfer rate is faster than high frequency systems, though still lower than microwave based RFID systems discussed next. Data transfer rates in this frequency band can have very different values that range from a few tens of kbps up to 800kbps. One drawback of ultrahigh frequency systems is a limited ability to read tags on objects with or surrounded by high water or metal content. Also, they are less resistant to reflections that occur due to the existence of obstacles than lower frequency RFID systems.

This is typically the frequency recommended for distribution and logistics applications. The primary rationale for utilizing this frequency in the supply chain is the greater read range it offers over the other frequency ranges. However, ultrahigh frequency RFID systems is also widely used for electronic toll collection systems on highways, manufacturing applications and parking lot access based on the greater range provided by the frequency.

D. Microwavwe band

The final frequency option is the microwave band, either 2.45GHz or 5.8GHz. Though microwave based RFID systems offer the highest data read rates which can go over 1Mbps. They are the most expensive systems although the tags are small and cheap to produce. RFID systems in this operating frequency band have a read range of up to 15m when using passive transponders. Additionally, microwave based systems are not able to penetrate objects with high water or metal content which makes it unsuitable for many applications. These RFID systems are the least resistant of reflections and other disturbances caused by presence of obstacle. The advantage of these RFID systems and systems operating in the ultrahigh band is the ability to read multiple tags simultaneously because of high data reading rate, which increase operating speed of RFID system.

At this time, microwave is constrained to specialized applications such as tracking airline baggage or electronic toll collection. Though it could be used for some supply chain applications with high data content, the inability to penetrate water or metal combined with the higher cost will limit its deployments in this realm.

IV. RFID Standards

As previously mentioned, there is no globally accepted universal standard for RFID systems. But, on the other side, there are several standards bodies that make effort in the development and definition of RFID technology standards, including:

- International Organisation of Standardisation (ISO);
- EPCglobal Inc;
- European Telecommunications Standards Institute (ETSI);
- Federal Communications Commission (FCC) and many other less important.

The ISO (International Standards Organization) and EPCglobal are leading figures in RFID standardisation. They developed many standards in this field, that are mutually incompatible in some sections, but they are commonly in use worldwide. Some of this standards, that are mostly used, as well as other previously discussed characteristics are given in Table I.

TABLE I
RFID CHARACTERISTICS OVERVIEW

Band	LF band	HF band	UHF band	Microwave band
Typical RFID Frequencies	125 – 134kHz	13.56 MHz	860 – 960 MHz	2.45 – 5.8MHz
Approximate read range	less than 0.5m	up to 1.5m	up to 8m	over 15m
Data transfer rate	less than 1kbps	25 kbps	up to 800 kbps	over 1Mbps
Applied standards: ISO	ISO 11784 ISO/IEC 18000-2A ISO/IEC 18000-2B	ISO/IEC 14443 ISO/IEC 15693 ISO 18000-3	ISO 18000-6A ISO 18000-6B ISO 18000-6C	ISO 18000-4 ISO/IEC 24730-2
EPCglobal			EPC: Class 0 Class 1 Class 1 Gen 2	

V. Practical Realization and Implementation of RFID System

For the purposes of the Digital Electronics Laboratory at the Faculty of Electronic Engineering, University of Nis, a system that performs control and track access to lab computers is developed. The system is composed of hardware terminal for interaction with users and software package on the server's side [6]. This hardware terminal is the primary focus throughout this paper.

For the design of hardware was used microcontroller from PIC18F family, that is the main part of hardware terminal in which appropriate firmware is embedded. This microcontroller performs overall operations of the hardware terminal. Other system components are graphic LCD display 128x64 dots with touch panel and RFID transceiver for interaction with users and their identification. For communication with the server via TCP/IP network, Ethernet controller ENC28J60 is used. RFID reader is selected to work at 125kHz operating frequency band because of several reasons. Some of them are: price, availability, ease of implementation and use of standard instrumentation without expensive tools for the design of high frequency system. Block diagram of described hardware terminal is given in Fig. 3.

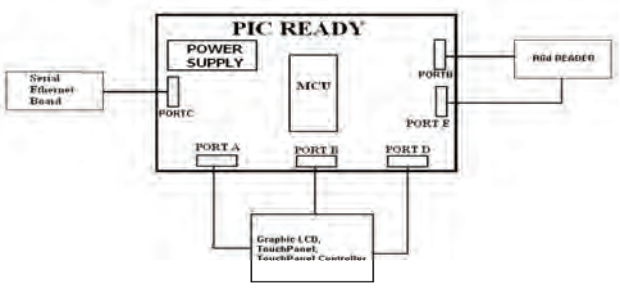

Fig. 3. Hardware terminal block dagram

VI. How System Works

The system works as following. While the inclusion of the system, on the display appears the message "PLEASE WAIT WHILE CONNECTION IS ESTABLISHED...", where assigning address from a DHCP server is checked.

After address is assigned to the terminal system and mutual communication with server is established, display gets following look, Fig. 4.

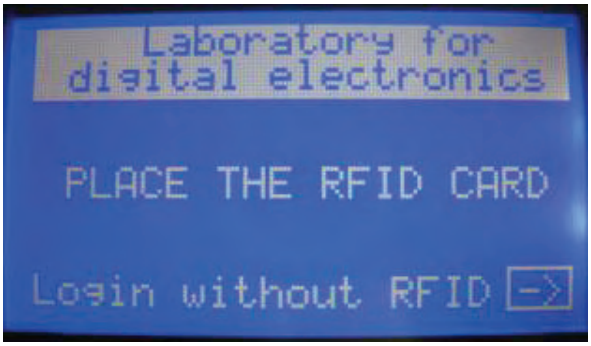

Fig. 4. The appearance of the initial screen

User logs in using RFID tags or, in case if there is no tag access enabled, directly through the touchscreen, and using PIN code that is entered via the keypad that appears on the touchscreen, as can be seen in Fig. 5.

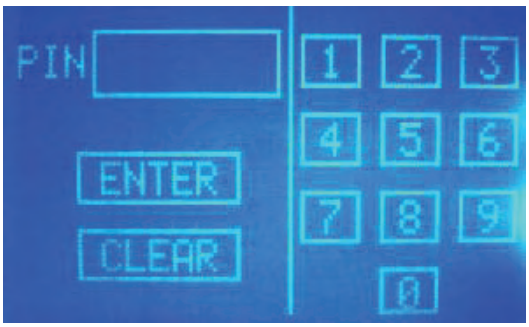

Fig. 5. The screen for entering the PIN code

If user enters a wrong PIN code or the number of RFID tag is not valid, following message will be displayed on the screen: “NOT VALID RFID OR PIN”.

If entered PIN code and RFID tag code (if RFID tag is used for accessing) matches with the values from the database on server, next picture will be displayed on screen, Fig. 6, allowing the user to select a free computer on which wants to work.

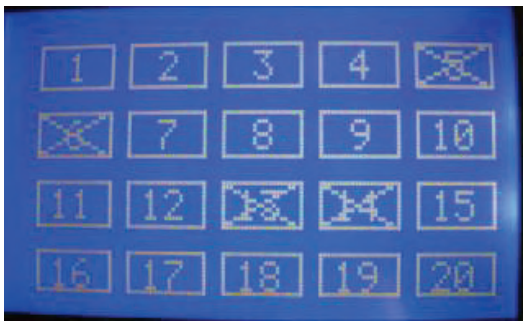

Fig. 6. Selection computer screen

If a crossed square with the computer numbers inside appears on the screen, it means that corresponding computer is busy and the user can not select it, while others are free to use. When the user selects the desired computer, the message of successful login to the computer is displayed on the screen, and then the system returns to the initial state where it waits for next user and previously selected computer starts with adequate access.

In case of losing communication with server, stoppage of packets receiving from it for defined time, the messages “BAD ETHERNET LINK” appears on the screen and than terminal retries to renew address from DHCP and restore communication with server. In this way the system is prevented from getting stuck.

This system is designed to be user friendly and easy to use. The system is very reliable and great attention to reducing in power consumption and increasing in speed is payed. Also, there is no possibility for system to stuck. Possible number of system users and computers, that system controls, is large enough and can be easy changed, which makes the system flexible for use. Look-out of assembled system is shown in Fig. 11.

Fig. 11. Look-out assembled system

VII. Conclusion

In this paper the description of RFID systems and their comparison from aspect of the operating frequencies are presented. An overview of characteristics of various RFID systems depending on operating frequency band and one concrete realization of RFID system for access control are given, too.

Lower frequency RFID systems use a larger-sized antenna to obtain the best transmission range and therefore occupy larger surface than the higher frequency RFID systems, that is disadvantage of lower frequency systems. Their speed of data transmission is quite slower and reading range is smaller in contrast to the higher frequency RFID systems, which is another disadvantage of lower frequency systems. They have advantages to work well in the presence of obstacles, as well as lower prices as opposed to high frequency system. Another advantage of lower frequency RFID systems is easier way of development and implementation, contrary to high frequency systems.

On the other side, described system for access control is successfully realized and implemented in Digital Electronics Laboratory at the Faculty of Electronic Engineering, University of Nis.

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