Radio Frequency IDentification, A TECHNOLOGY FOR THE FUTURE ?

Smail TEDJINI, Tan-Phu VUONG

Grenoble INP-LCIS - Laboratoire de Conception et d'Intégration des Systèmes,
ESISAR, 50, Rue B. de Laffemas, B.P. 54, 26902, Valence, France
smail.tedjini@esisar.inpg.fr

Abstract

RFID is one of the most relevant wireless technologies, and it can be seen as the first communicating object. This paper will briefly describe the principle of RFID and its development since its introduction in 1948. Important examples of RFID applications will be presented and discussed in term of advantages and limitations in the frame of communicating object. RFID chips are integrating more and more embedded electronic and data processing which allows the RFID to be considered as the gate way for the Internet of things.

1. Introduction

The first publication on RFID concept is due to Harry Stockman who introduced the basic concept of the "communication by means of reflected power" [1]. During the 1950s several technologies related to the RFID were explored, among them, the very popular transponder system "Identification, Friend or Foe: IFF" for aircraft. The 1960s were the prelude to the RFID explosion [2]. R.F. Harrington developed the electromagnetic theory related to the RFID application [3,4]. Commercial activities exploiting the RFID began also during the 1960s and the Electronic Article Surveillance (EAS) application is one example. It is "1-bit" tag since only the presence or the absence of a tag can be detected [5]. In the 1970s, and under the impulse of microelectronics, companies, universities and government laboratories were actively engaged in the development of practical applications of RFID. Many examples can be found in [5], among them animal tracking, vehicle tracking and factory automation. Even if the interest was different between Europe and US, the 1980s was the decade for mass deployment of RFID technology. The interest in the US was mainly for transportation and access control. In Europe the greatest interests were for animal tagging, industrial applications and toll roads. Since the 1990s many technological developments are dramatically expanding the functionality of the RFID. Advances in microelectronics, RF, embedded software are opening the door to numerous new RFID applications and making real some of our dreams. Among these applications, the verichip tag is a very polemic example since it consists in tagging humans. In 2004, the U.S. Food and Drug Administration, which regulates medical devices in the United States, approved an RFID tag for implantation in humans as a means of accessing a person's health records [6]. Today, the novel frontier of RFID is the "Internet of Things" . This term describe a number of technologies and research projects that enable the Internet to reach out into the real world of physical objects. Technologies like RFID, short-range wireless communications, and sensor networks are now becoming increasingly common, bringing the Internet of Things into commercial use. This is an exciting future that closely interlinks the physical world and cyberspace [7].

2. RFID System

Radio-Frequency IDentification (RFID) [5] wireless systems generally consist of three parts :

- Reader or base station : a fixed or mobile interrogator which communicates with tag.
- Tag : a small mobile communication circuit embedded on radiating element.
- Information system : a data base that gathers the information to be processed

Depending on applications and frequency, RFID tags can be categorized as either active or passive. Usually due to the mobility of the tags, they can be active when powered by an internal battery. Passive tags operate without internal battery source but in practice they get their operating power from the signal coming from the reader. Thus, passive tags are consequently much lighter and potentially low cost than active tags. However, active tags have larger communication distances. In term of communication, RFID has four frequency bands summarized on Table 1 :

Band	LF	HF	UHF 900MHz	Microwave
Frequency	**125kHz** **134.2kHz**	**13.56MHz**	**400 MHz** **865 to 869 MHz, Europe** **902 to 928 MHz, USA** **952 to 954 MHz, Japan**	**2.45GHz** **5.8GHz**
Example of Applications	security, access control, animal id.	tolling, transport app., e-passport	Container Logistic Item	Distribution Retail

Tab. 1. RFID frequency bands

From wireless point of view LF and HF operate under the near field regime of antenna elements and this will limit the communication distance to less than roughly one meter. However, at these frequencies, many reliable and low cost electronic processing circuits are available and allow large diversity of applications. For larger communication distances UHF and microwave bands are more suitable since typical reading distance is 3 to 10 meters (under 4 W power emission).

On Chip side, the advances in IC technologies, especially CMOS [8,9], and integration as well as the increase in the demand of RFID systems are cutting down the cost RFID tags. There are numerous applications requiring low cost and small size tags, among them item labeling, bagage tracing and tracking. EPC class 1 generation 2 is the most accepted RFID protocol today. This is an open standard that creates an interoperable environment internationally used.

The antenna design for tags was strongly studied in the previous years, and today many solutions corresponding to different applications are available. The challenge was to design compact and matched antenna (to the chip impedance) on unusual substrates [10]. To respond to this demand, fast and low cost manufacturing process involving printing process has been developed: including screen, flexography and gravure printing. An overview of the RFID label manufacturing is presented in [11]. Some examples of low cost tags are given on figure 1.

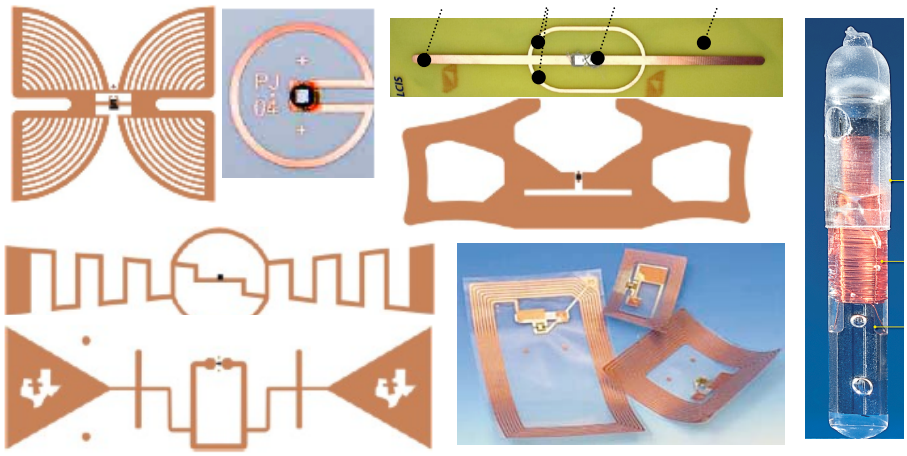

Fig. 1. Different tags corresponding to LF, HF and UHF Tags.

3. RFID APPLICATIONS

The availability of efficient, compact and low cost tags allows today, to consider the use of RFID as an enabling technology in a large variety of applications and situations. Some knowledgebase identify more than 3000 study case [12]. This huge number of study demonstrates that RFID will be considered in the near future for wide variety of purposes in an extremely wide variety of locations and situations. Today, Item and pallet tagging, people and security identification are the sectors corresponding to the largest number of study using RFID. In the previous cases, the RFID tag is mainly used as an identifier, somewhat similar to the well known barcode. However, more complex and sophisticated applications can be achieved if we consider all the functionalities that IC chip can offer.

In its simplest form, the IC chip contains only a read only memory (always 128 bits) with a fixed and unique identifier. One example of very compact IC is the µ-chip developed by Hitachi which operates at 2.4Ghz and it has a surface of less than $1mm^2$ [13]. At the other side, the IC chip can integrate, in addition to ROM, RAM and EPROM. It can also integrate some sensors for temperature, vibration … which will greatly extend its functionality in term of data capture and processing.

Even if RFID is an Identification method, it is more than just "the next barcode" technology. Embedded electronic and software on the tag creates a variety of interfaces to connect computers directly to physical items and to connect Things to Things. This potentiality is known as the internet of things. This concept emerged from the Joint Total Asset Visibility (JTAV) [14] which is a network built by the US DoD in the last decade. JTAV is the larger RFID network in the world, it uses active RFID tags and GPS devices to track and localize military supplies.

This combination of RFID with GPS was recently introduced by china in order to ensure online traceability of containers traveling between Shanghai and Savannah in USA. The method will be extended to routes between china and europe. This kind of combination will continue to extend the field of application not only for RFID but for communicating objects.

4. Conclusion

Nowadays, RFID is a well established technology and is currently used for the identification, since it shows many practical advantages when compared to well known barcode technology. However, embedded software, electronics and RF on RFID tag greatly extend the field of applications of RFID. Today there are worldwide many studies considering the RFID as an enabling technology for a variety of applications. RFID tags may be located on anything. There are RFID tags on humans, animals, vegetables, items … The combination of RFID with other technologies like GPS, Telephones, Payment systems … is expanding its field of application. One of the important development of the RFID is the so-called Internet of Things and smart dust. Advances in nanoelectronics, RF communications and embedded software will greatly contribute to the emergence of this field.

Whatever the technology development, the social debate is emerging and will continue its development. The benefits of RFID are undeniable. The example of implantable Chip is very significant. Information stored on the chip will probably help physician to know you health state even if you are unconscious. But, what about your privacy and body integrity ?

5. References

[1] H. Stockman "Communication by means of reflected power", Proc. IRE pp 1196-1204, 1948

[2] J. Landt "*Shrouds of Time, The history of RFID" An Aim. Publication. 2001.* *www.aimglobal.org/technologies/rfid/resources/shrouds_of_time.pdf*

[3] R.F. Harrington, *"Small Resonant Scatterers and Their Use for Field Measurements"* Microwave Theory and Techniques, IEEE Transactions ,Vol. 10, N° 3 , May 1962 pp165 – 174

[4] R.F.Harrington *" Field Measurements Using Active Scatterers"* Microwave Theory and Techniques, IEEE Transactions. Vol.11,5, Sep 1963 pp 454 - 455

[5] K. Finkenzeller *"Fundamentals and Applications in Contactless Smart Cards and Identification*" 2nd edition, Wiley & Sons LTD April 2003.

[6] Kenneth R. Foster and Jan Jaeger "RFID inside" IEEE Spectrum, march 2007.

[7] http://www.smart-systems-integration.org/public/internet-of-things/documents/080207_Joint_EC-EPoSS_ExpertWS_Frameworkpaper.pdf

[8] P. B. Khannur, et al., "An 860 to 960MHz RFID Reader IC in CMOS", IEEE Radio Frequency Integrated Circuits Symposium, 2007, pp: 269- 272

[9] N. Tran, et al., "Development of Long-Range UHF-band RFID Tag chip Using Schottky Diodes in Standard CMOS Technology" IEEE Radio Frequency Integrated Circuits (RFIC), 2007, 3-5 June, pp:281 - 284

[10] D. Bechevet, T.P. Vuong; S. Tedjini, "Design and measurements of antennas for RFID, made by conductive ink on plastics," IEEE Antennas and Propagation Society International Symposium, 3-8 Jul. 2005

[11] M. Fairley, "RFID Smart Labels – A 'How to' Guide to Manufacturing and Performance for the Label Converter," second edition, Labels and Labeling.

[12] IDTechEx Knowledgebase, www.IdtechEx.com

[13] www.hitachi.co.jp/Prod/mu-chip/

[14] Yi Tian Chen et al, "Application of WLAN in JTAV" Microwave, Antenna, Propagation and EMC Technologies for Wireless Communications. MAPE 2005. IEEE International Symposium on Volume 2, 8-12 Aug. 2005 Page(s): 1394 - 1397