Experimental Survey on RFID Technology & Adaptable Specification for Emerging Applications

E. P. Prakash / Assistant Professor
Department of Computer Science and Engineering,
SNS College of Engineering
Tamilnadu, India

Kishore Ravichandran
Department of Computer Science and Engineering,
SNS College of Engineering
Tamilnadu , India

***Abstract*— Radio Frequency Identification (RFID) facilitates automatic identification of items using radio-waves. This technology has seen a drastic increase in the number of applications and implementations in the recent years. This work aims to review some of the current developments in this field and to develop a taxonomic framework to classify literature which will facilitate quick content analysis and identify future direction of research on RFID applications. RFID tags are small, wireless devices that help identify objects and people , they are likely to proliferate into the billions in the next several years – and eventually into the trillions. RFID is versatile tags which are becoming very small and their dimensions are also reducing to 0.002 inches (RFID powder tag). There are many different types of RFID tags available in the market for different types of applications. Due to reduction in the cost of production, RFID systems are being deployed everywhere in large number. Therefore, it becomes important to understand the tag technology and their applicability. In this paper, we provide a comprehensive survey of various RFID tag technologies. The intended purpose of this survey is to further extended academic research and examine the suitable RFID for the library book access.**

***Keywords* : Radio Frequency Identification , wireless devices , RFID powder tag**

I. INTRODUCTION

The Radio Frequency (RF) technology has a wide area of applications like television, radio, cellular phones, radar, medical and automatic identification systems. Radio Frequency Identification (RFID) originated during World War - II [44] when it was imperative to determine whether combatants were “friend or foe” in 1948, but the commercial products based on RFID came in 1980s only. The radio waves used in RFID are Low Frequency (LF)- 125 KHz to 143 KHz, High Frequency (HF) 3MHz to 30 MHz, Ultra High Frequency (UHF) 300MHz to 1 GHz, Microwave frequency (MW) > 1 GHz. The RFID is an automatic data capture systems (AIDC) that is a contactless and uses RF signals for communication. The data is stored on silicon chips (tag memory), which has been tagged to the target like books, parcels, human, animal, or other non-living objects. The RFID provides a unique identification number for identifying the particular objects known as electronic product code (EPC)[12].The reader sends continuous waves (CW) through which tag drives power supply in order to operate the chip. RFID tag stores and transmits the data to the reader in a contactless manner using radio waves by a technique known as backscattering. The information can be a product ID or manufacture ID of specific product.

The RFID tag consists of an electronic chip to which an antenna is attached. Some passive (semi) tag contains a battery, to supply the power to auxiliary electronic circuit. The tag plays very important role in any RFID application. There are various methods to classify a tag based on their characteristics. The tag is distinguished based on power source, frequency and functionality. The size of the tag (form factor) has also an important role in size constraint applications

II. TAG CLASSFICATION AND CONFIGURATION

An RFID tag is a microchip combined with an antenna system in a compact package as show in figure 1[4]. The microchip contains memory and logic circuit to receive and send the data back to the reader. The antenna receives signal from an RFID reader and then backscatters the signal with required data.

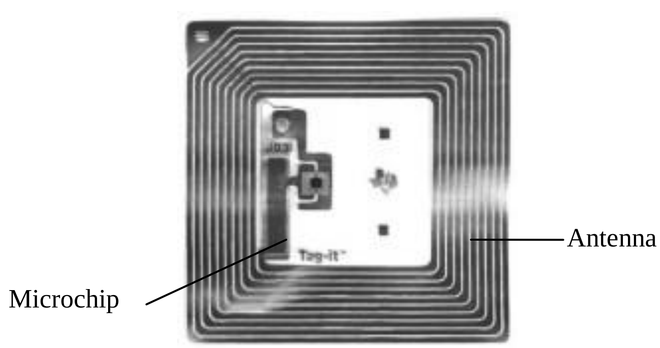

Figure 1. RFID Tag

S. NO.	CRITERIA	TYPES
1	Identification format	64-Bit EPC Tag, 96-Bit EPC Tag,128-Bit EPC Tag etc
2	Power Source	1. Passive 2. Semi-passive 3. Active
3	Frequencies	LF, HF, UHF
4	Functionality	1. Memory (Size, Read/Write) 2. Environmental sensors 3. Security functionality
5	Form Factor	1. Size/Shape of the tag 2. Digestible, implantable 3. Weight of the tag 4. The method by which the tag is affixed

TABLE 1. TAG CLASSIFICATION CRIITERIA

The RFID tags can be broadly classified in three major Different Categories As Follows:

1. Based on 'on-board' power supply
2. Based on capacity to rewrite the data
3.Based on reading range of the RFID

However, we have classified the tag based on various parameters like Identification format, frequencies, and form factors etc. as shown in table 1. There are tags available in the market, which are digestible in the human body. Theses tags are used in medical diagnosis. The tag can be classified into two or more categories viz. based on power source, based on form factor, based on operating frequency etc.

We have another classification that is based on the content and format of the information. This classification is based on EPC Global standard as shown in table 2[12].The EPC classification has potential to change the way many companies do business operations to meet the standard and allow business to share information effectively.The classification of tag based on the format, reader/write capability and programming capability is as shown in table 3. The EPC classification consists of Class and Generation. The Class describes a tags basic functionality for example whether it has memory or an on-board power source whereas Generation refers to a tag specification's major release or version number.

1. CLASSFICATION BASED ON 'ON-BOARD' POWER SUPPLY

In general, we classify the tag into passive and active categories. The passive tag has no 'on-board' power source. They extract power from the signal (CW) sent by the reader that is used to operate the chip. The absence of battery makes their size smaller. The active tag has 'onboard' power source. This 'on-board' power source is used to transmit the data from the tags to the reader, and this power is also a source for other electronics components of the tags present in the tag. In the passive tag, the reader initiates the communication whereas in active tag, the tag initiates the communication. A semi passive tag is passive in nature, but it contains a battery to supply power to auxiliary components like sensors, user interface etc.

TABLE 2. EPC CLASS STRUCTURE

EPC CLASS	DEFINITION	PROGRAMMING
Class-0 Gen-1	Read Only, Passive tags	Programmed by the factory
Class-1 Gen-1	Write-Once, Read-Many, Passive tags	Programmed once by the user then locked
Class-1 Gen-	Write-Many, Read-Ma passive tags.	Programmed once by user then locked
Class-2	Rewritable passive tags with extra functionally like encryption, emulation [3]	Re-programming
Class-3	Semi-passive tags that supports broadband communications	
Class-4	Active tags that can communicate to other peers.	
Class-5	Readers, they can power other tag of class (I, II, III) and as well can communicate to class IV wirelessly.	Not applicable

1.1. PASSIVE TAGS

Passive tags do not have an integrated power source and are powered from the signal carried by the RFID reader.

Generally, these tags are powered by the reader antenna through an antenna located on the tag. The reader's transmission is coupled to the specially designed antenna through induction or E-field capacitance which generates a small voltage potential. This power is then used by the IC to transmit a signal back to the reader or reflect back a modulated, encoded identification.

Communications techniques:

The communication flow in the RFID system is in either the reader-to-tag or tag-to-reader direction depending on the type of tag. In passive tag, the EPC/information is sent to the reader by reflecting, or backscattering. A pictorial representation of transmitted energy between tag and reader is shown in figure 2

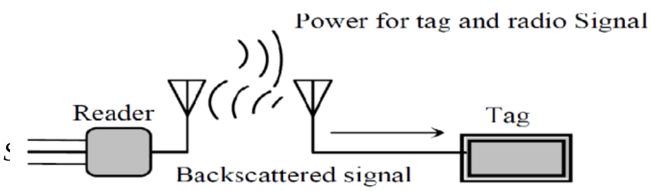

Fig.2.Communication Between Reader And Passive Tag

The passive tag consists of microchip (memory and logic) and antenna as shown in figure 3.The Rectifier shown in the figure 3 converts the AC power into DC power from reader and the extracted power is used for other components of the tag like memory/logic circuit etc. in order to interpret the command, the demodulator block demodulates the received signal from the reader.

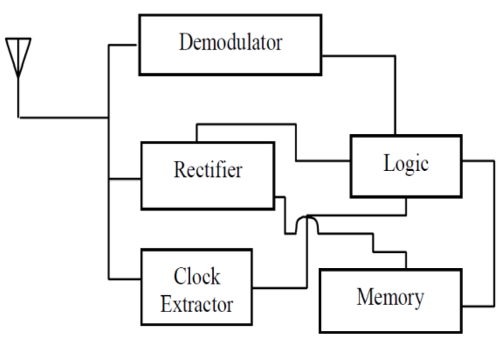

Fig 3.Block Diagram Of Passive Tag

The reader can send read command to read the data from tag's memory. The communication protocols (EPC standard) are implemented in the logic circuit of the tag. The clock extract is used to generate the clock in order to synchronize with reader clock. A detailed schematic of passive RFID tag is shown in figure 4.

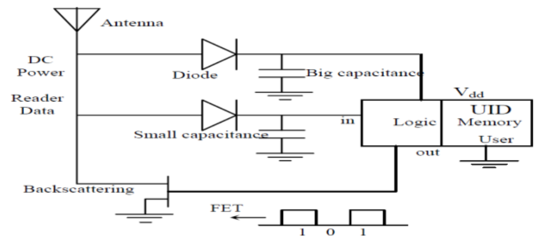

Fig.4 Schematic Of Passive Tag

In this, antenna receives electromagnetic field from the readers producing a voltage signal of high frequency (RF). The voltage is rectified by a diode (which allows current flow in one direction only) and smoothen using a storage capacitor. This would produce a DC like voltage, which is used to energize the logic unit and the memory unit of the passive tags. The other rectification circuit is used for extracting the reader data command. For sending the tag data i.e. EPC/ID to the reader, the tag simply changes the electrical co-efficient property of the antenna, which changes the signal reflected from the antenna. This process is called backscattering [1]. In the diagram above, we used a Field Effect Transistor (FET) as a switch when it's 'ON' the antenna is grounded and a large current flows and when the FET is 'OFF', a small current is allowed to Flow.

1.2. SEMI PASSIVE TAG

Semi-passive tags have an on-board power source, such as a battery, which is used to run the microchip's circuitry. However these tags utilize a battery but still operate using backscatter techniques. Tags of this type have greater range than totally passive tags and have the ability to monitor sensor inputs even when they are not in the presence of an RF field. The semi-active tag also has 'on-board' battery but this battery is used for driving the auxiliary electronics (sensors, user-interface etc) circuit only. The data to the reader is sent using backscattering technique. The semi passive tags, reader always initiates the communications as shown in figure 5.

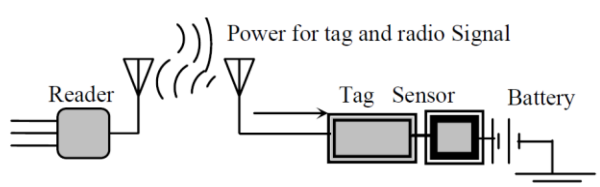

Fig 5.Communication Between Reader And Semi passive Tag

The schematic of semi-passive tag is similar to the passive tag except the DC power sources is attached for auxiliary circuit like sensor, user interface etc.

1.3.ACTIVE TAG

Active tags incorporate a battery to transmit a signal to a reader antenna. These tags either emit a signal at a predefined interval or transmit only when addressed by a reader. Either way, the battery provides the power for RF transmissions, not an inductive or capacitive coupling. As a result of the built-in battery, active tags can operate at a greater distance and at higher data rates, in return for limited life, driven by the longevity of the built in battery, and higher costs. For a lower cost of implementation, passive tags are a more attractive solution

Communication Techniques:

Unlike passive tag, active tags has 'on-board' power source. This power is used to deliver energy for transmitting the data from the tag. This energy is also a source for other electronics components of the tags present in the tag.

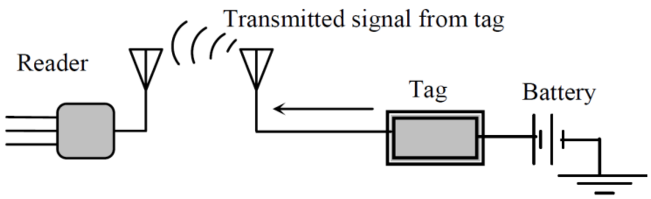

Fig 6. Communication Between Reader And Active Tag.

Schematic Of Tag:

The active has on-board power supply, control circuitry and transmitter to receive/send the data. A detailed schematic is shown in figure 7, where tag synthesizes the carrier signal by a local oscillator (LO) and a crystal reference. This enables tag to select a specific frequency band using one of modulation technique (ASK, PSK,FSK, QAM) depending upon requirement. The transmit power, filter and amplification are used to produce good receive sensitivity, due to which the read range of the tag is measured to be hundreds of meter or more.

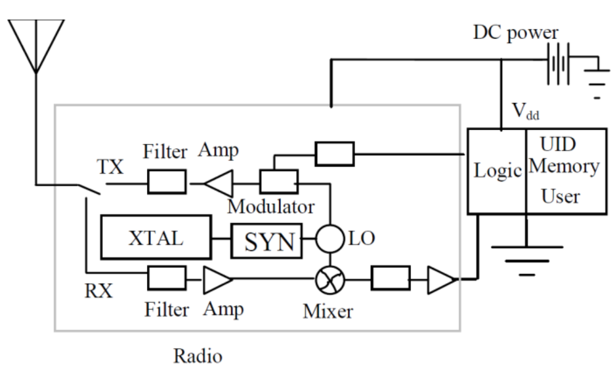

Fig 7. Schematic diagram of active tag

2. COMPARISON OF RFID TAGS BASSED ON POWER SUPPLY BOARD

TABLE 3. COMPARISON TABLE OF RFID TAGS

Characteristics	Passive RFID	Active RFID	Semi-Passive RFID
Frequency (UHF)	860MHz -960 MHz	868/915MHz and 2.4 GHz	868/915MHz and 2.4 GHz
Internal Power	No	Yes	Yes
Bit Rate (Kbps)	246	20/40/250	16
Memory (KB)	128	128	4
Multi –Tag Collection	3 sec. to identify 20 tags	1000 tag / sec at 100 mph	7 tags / sec at 3 mph
Read Range	1-30 ft.	1-300 ft.	Up to 15 ft.
Cost	INR 10-150	INR.1250-2500	INR 500-2000
Life Time	3-10 years	½ -5 years	½ -5 years

3. CLASSFICATION OF RFID TAG BASED ON CAPACITY TO REWRITE DATA:

Read-Only:

The information stored must be recorded during the manufacturing process and cannot be typically modified or erased. The data stored normally represents a unique serial number, which is used as a reference to lookup more details about a particular item in a host system database. Read-only tags are therefore useful for identifying an object, much like the "license plate" of a car.

Write-Once:

These differ from read-only tags in that they allow the end-user to program the tag's memory. Therefore, as an item progresses down a conveyor, for example ,an end-user can encode a write-once tag with the item's serial number or part number which cannot be erased.

Read-Write:

In this data can be written and erased on demand at the point of application. Since a rewriteable tag can be updated numerous times, its reusability can help to reduce the number of tags that need to be purchased, and add greater flexibility and intelligence to the application. Additionally, data can be added as the item moves through the supply chain, providing better race ability and updated information. Advanced features also include locking, encryption and disabling the RFID tag.

4. CLASSFICATION OF RFID TAGS BASED ON READING RANGE:

4.1. LOW FREQUENCY:

These RFID systems operate in the 30 KHz to 300 KHz range, and have a read range of up to 10 cm. While they have a shorter read range and slower data read rate than other technologies, they perform better in the presence of metal or liquids (which can interfere with other types of RFID tag transmissions). Common standards for LF RFID include ISO 14223 and ISO/IEC 18000-2. LF tags are used in access control, livestock tracking, and other applications where a short read range is acceptable.

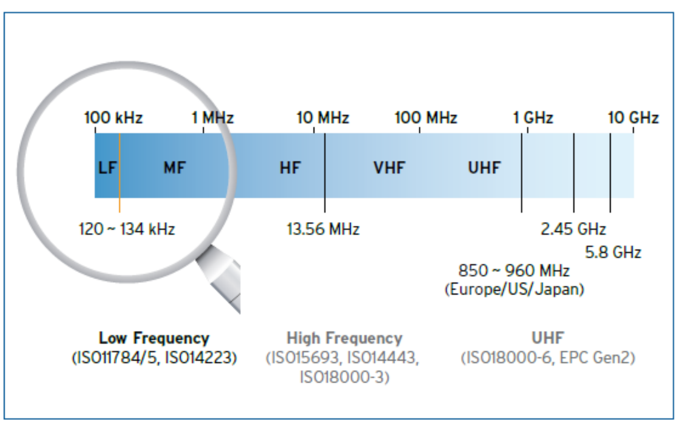

Fig 8. Frequency Range Of LF RFID

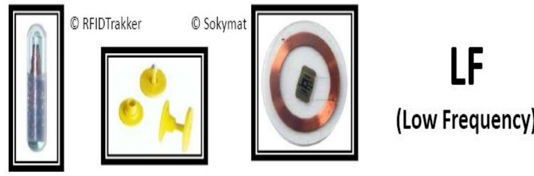

Fig 9. Low Frequency Tags

4.2. HIGH FREQUENCY:

HF systems operate in the 3 MHz to 30 MHz range and provide reading distances of 10 cm to 1 m. Common applications include electronic ticketing and payment and data transfer. Near Field Communication (NFC) technology is based on HF RFID and has been used for payment cards and hotel key card applications. Other types of smart card and proximity card payment and security systems also use HF technology. Standards include ISO 15693, ECMA-340, ISO/IEC 18092 (for NFC), ISO/IEC 14443A and ISO/IEC 14443 (for MIFARE and other smart card solutions).

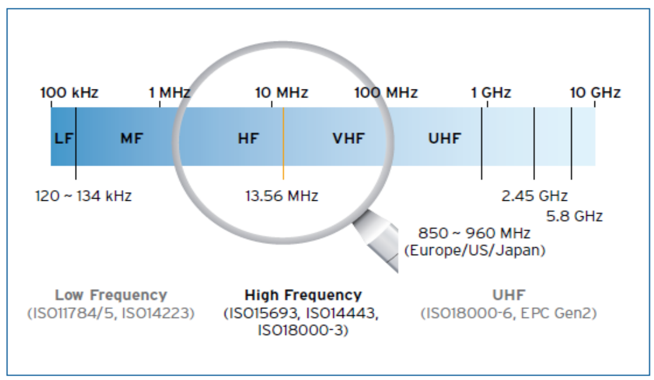

Fig 10. Frequency Range Of HF RFID

Fig 12. High Frequency Tags

4.3. ULTRA HIGH FREQUENCY:

These systems have a frequency range between 300 MHz and 3 GHz, offer read ranges up to 12 m, and have faster data transfer rates. They are more sensitive to interference from metals, liquids, and electromagnetic signals, but new design innovations have helped mitigate some of these problems.UHF tags are much cheaper to manufacture, and as such are commonly used in retail inventory tracking, pharmaceutical anti-counterfeiting, and other applications where large volumes of tags are required. The EPC global Gen2/ISO 18000-6C standard is a well-known global standard for item-level tracking applications. Today's Gen 2 UHF RFID tags make RFID an affordable reality. Unlike active tags, these passive tags do not require their own power source — the reader provides the power to initiate the transmission of data. Since less technology is required in the tag, their cost is very low. A low cost RFID tag means you can tag and increase visibility into more of the goods, products and assets which drive your revenue stream. The tags can be re-used, easily updated with new data. And since these tags can be read from near contact to as far as 30+ feet away,1 you can use them on nearly any type of asset. The result is a rapid return on investment (ROI) in as little as six months to a year — even for the largest of organizations.

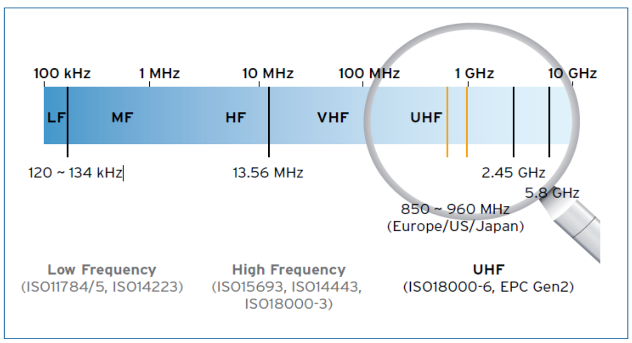

Fig 13. Frequency Range Of UHF RFID

UHF RFID brings value to virtually any business that has bulk items to manage — from product moving through the supply chain to inventory to equipment. In the following pages, you can see the benefits of UHF RFID solutions in:

Industries

- Retail
- Distribution and Warehousing
- Manufacturing
- Government
- Energy: Utilities, Oil and Gas
- Healthcare

Horizontal Applications

- Asset Management
- IT Asset Management
- Returnable Transport Items (RTIs)
- Track and Trace: Cold Chain/Food Safety

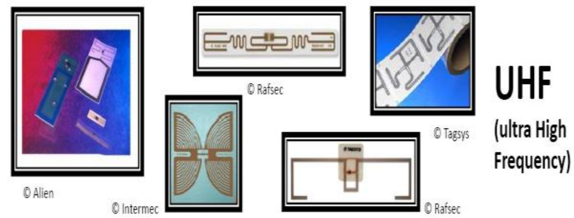

Fig 14 Ultra. High Frequency Tags

5. COMPARSION OF RFID TAG BASED ON READING RANGE

LF, HF and UHF Passive RFID use magnetic coupling to transfer power and data. UHF Passive and Active RFID are based on e-field coupling. The type of coupling affects factors such as read distance, data rate and environmental robustness. True physical tag maximum read distance is determined by the individual RFID reader and antenna power, the actual Integrated Circuit used in the RFID tag, the material and thickness of material the tag is coated or covered with, the type of antenna the tag uses, the material the tag is attached to and more While a specification may show a theoretical RFID tag read range of 5 meters (ideal conditions) it may be as little as 1 meter if the tag is attached to an object that is sitting on a metal surface surrounded by water and electromagnetic waves (not ideal conditions).

Parameter	Technology			
	LF Passive <135 kHz	HF Passive 13.56 MHz	UHF Passive 868 – 950 MHz	UHF Active 433 – 5.8 Ghz
Read distance	high	low - medium	high	highest
Data rate	4 kbps to 8 kbps	6.7 kbps to 848 kbps depending on protocol	Freq/1, LF/2, LF/4, LF/8*	Freq/1, LF/2, LF/4, LF/8*
Multi tag reading	10s	100s	1000s	1000s
Form factor flexibility	high	high	medium	low
Environment				
Tissue/Water Metal	No absorption controllable	Lim. absorption controllable	Strong absorption reflection	Lim. absorption controllable

III. CONCLUSION

In the presented work, we have discussed various types of tag technology that are available in the market. We have broadly classified tag based on five major criteria. The classification based on the EPC Global standard is also discussed in detail. Each tag has some strength and weakness, which are reported in the characteristics of the tag. The working principle, communication technique and schematic show the data flow of tag. Therefore, understanding of classification, communication techniques, architecture, application of tag becomes very much useful for end-user as well as for the designer RFID has been hailed as one of twenty-first century's greatest contributions. RFID implementations are increasing at an unbelievable rate with it making inroads into areas as diverse as supply chain, health-care, transportation and even bike rentals . However, from the above literature review, it can be concluded that standardization of hardware, software, network protocols and reading devices is important. Moreover, from this survey we conclude that UHF RFID with semi passive range will be more efficient for forthcoming RFID applications since the accuracy , cost of implementation , and methods are so easy to work. And we choose UHF RFID in semi passive range for the library book searching process which will give better resultant in searching issues

REFERENCES

[1] Nikitin, P.V.; Rao, K.V.S –Theory and measurement of backscattering from RFID tags‖, Antennas and Propagation Magazine, IEEE Volume 48, Issue 6, Dec. 2006 pp. 212 – 218

[2] Pongpaibool, P –A study on performance of UHF RFID tags in a package for animal traceability application‖ ECTI-CON 2008. Vol. 2, 14-17 May 2008 pp 741 – 744

[3] Khan, M Ayoub, Sharma Manoj, R Brahmanandha Prabhu–FSM based Manchester Encoder for UHF RFID Tag Emulator‖ IEEE ICCCN 2008, Karur, Tamilnadu, pp 1-6

[4] K. Finkenzeller, –RFID Handbook: Fundamentals and Applications in Contact less Smart Cards and Identification‖, John Wiley & Sons; 2 edition, 2003. pp392

[5] Sandip Lahiri –RFID Sourcebook‖ Prentice Hall PTR August 31, 2015

[6] The RF in RFID Passive UHF RFID in Practice by Daniel M Dobkin USA, ISBN 978-0-7506-8209-1

[7] http://www.rfidjournal.com/article/view/961 Date: March 2, 2016

[8] http://www.caen.it/rfid/military_civilian.php Date: March 2, 2009

[9] www.nextnature.net Date: January 06, 2016

[10] http://www.engadget.com/2016/02/14/hitachis-rfidpowder-freaks-us-the-heck-out/ Date: January 07, 2016

[11] http://www.pinktentacle.com/2016/02/hitachi-developsrfid-powder/ Date: January 07, 2009

[12] www.epcglobalinc.org/ Date: Jan 10, 2016

[13] www.rfidgazette.org/walmart/ Date: Feb 20, 2016

[14] www.gilbarco.com/pdfs/P2319.pdf Date: Feb 20, 2016

[15] www.hitachi.co.jp/Prod/mu-chip/ Date: Feb 20, 2016