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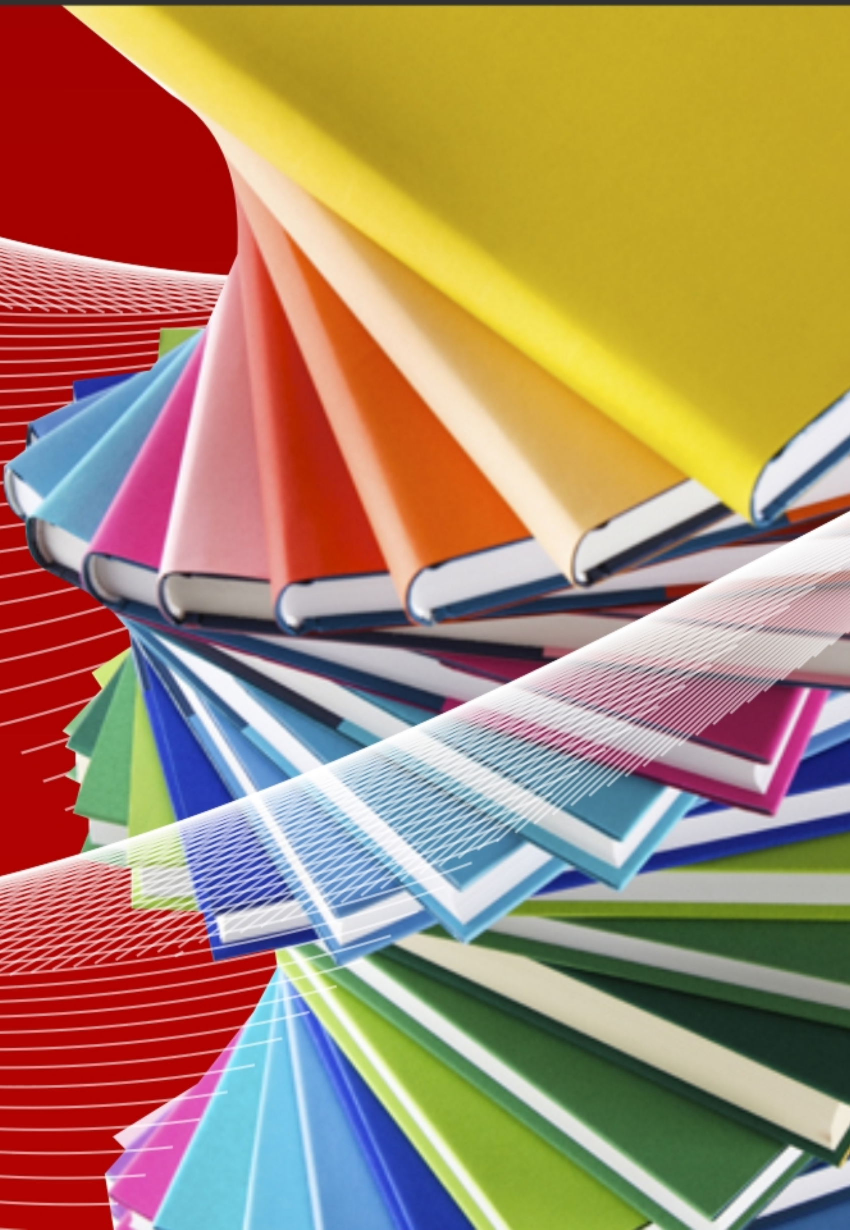

GENERALIZED RFID CONTROL USING POSTURE EFFECT ON TAG DETECTION FOR VISION IMPAIRED

by

Ip Chun In

Final Year Project Report submitted in partial fulfillment
of the requirements for the Degree of

Bachelor of Science in Electrical and Computer Engineering

2015

Faculty of Science and Technology
University of Macau

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Signature : ____________________________

Supervisor : Prof. Dr. Tam Kam Weng

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ABSTRACT

This project is about the design and implementation of generalized RFID control using posture effect on tag detection for vision impaired (or visual impairment person, VIP). There are two parts in this work including VIP’s Radio Frequency Identification (RFID) cane design and test using UHF RFID passive tag operated at 920 MHz and; Received Signal Strength Indication (RSSI) of UHF RFID tag attached to the cane in different orientation is used to realize generalized control mechanism for VIP. To validate the system practical, a prototype UHF RFID cane and its control system is designed and tested aligned with possible postal service for VIP in Macau. It is believed that such RFID cane based on passive tags allows an implementation of economic and smart information system development for VIP in future.

For the design of RFID cane, a two-tag cane with 100 cm length is studied in consideration of tag’s linear polarization. These two tags are arranged around 70 cm in horizontal and vertical position respectively in reference to the cane end. For a trial tag detection in 110 cm apart from the reader, due to the polarization effect of VIP’s cane vertically holding posture, the horizontal and vertical tags provided -64 dBm and -74 dBm of RSSI respectively whilst the horizontal posture holding only reported -55 dBm and 0 dBm of RSSI yielding more than 10 dB and 50 dB differences. Therefore, a control mechanism of “ON” and “OFF” signal can be differentiated. Additional tag-reader distances were studied, 8 dB, 3 dB, 7 dB for 120 cm, 160 cm, 190 cm when posture effect was implemented by different holdings of the cane with different angles. Moreover, the experiment aimed to test about whether the materials such as iron, copper and plastic will affect the effectiveness of the tags or not had been included in this project.

Nowadays, the postal service for VIP needs further attention in Macau. The above RSSI signal phenomena of two-tag RFID cane was used to develop a RFID enable postal service for VIP. In fact, the control system for the function of printing, voice to text or “Text to Voice” can be integrated to build a “Kiosk”. According to principle of the control mechanism of “ON” and “OFF”, the “Kiosk” can acts as a postal services center with different functions which is controlled via the different holdings of the RFID cane.

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CHAPTER 1 INTRODUCTION

1.1 Background

Radio Frequency Identification (RFID) as in Fig. 1.1 is a system which radio waves to exchange the data between a reader and a tag attached to an object. For the purpose of identification and tracking.

The operation of the RFID can be classified depending on the requirement of frequency of the application like low frequency (LF), high frequency (HF), ultra high frequency (UHF) and microwave frequency (MW). Because of the inductive coupling for communication, LF and HF can be only used for a short range communication. However, the UHF communication is used on the basic backscattering technology. It means that the tags are powered by a continuous electromagnetic wave generated by the reader. The tags can absorb the radio frequency (RF) energy to operate the chips themselves. Nowadays, the most common method of identifying objects is barcode because of its maturity and economic advantage. However, barcode technology suffers from the intrinsic limitation such as the requirement of line-of-sight (LOS) operation. Hence, the UHF can overcome the limitation such as LOS, short communication range, and single access at each time. Moreover, multiple tags can be accessed at each time, and the data can be read and written into individual tag. Besides, the backscattering modulation of UHF RFID allows to approach to many sensing scenario such as civil engineering, of material detection.

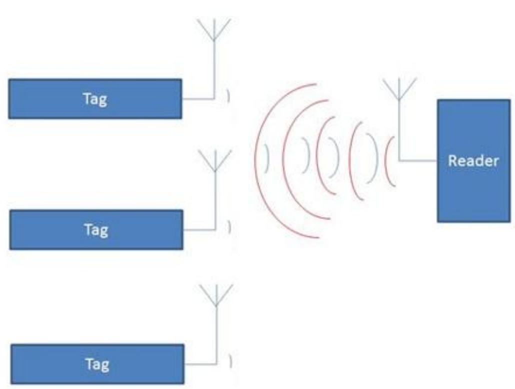


Fig. 1.1 A general architecture of RFID

1.2 Intelligent System for Visual Impairment Person (VIP)

At 2010, it is said that the Visual Impairment is still an essential problem from the data supported by World Health Organization [1]. These circumstances, the development of IT systems for the VIP become more important than before. Moreover, the system mainly focus on solving the problem of the VIP such as navigation, positioning and safety. The examples of the products for the VIP are:

- Cane
- Thimble

1.2.1 I-Cane

There are approximately 15.5 million people in Europe, 40,000 in Netherlands [2] and 300,000 in Australia [3] are visually impaired. It is believe that some of them will be able to benefit from advanced assistive technology being developed by I-Cane [4] that is a project has a total eligible budget of EUR 692 800 with the EU's European Regional Development Fund contributing EUR 346 400 for the 2007 to 2013 programming period. It is indeed a unique pedestrian guidance device as shown in Fig.1.2. Using I-Cane helps the VIP to find a 'free path' based on an innovative method of combining sensors, mechatronics and algorithms. The obstacles can be detected along the route and I-Cane provides the user with the information VIP needs to walk safely.

Fig. 1.2 I-Cane [4]

This system is considered as a pioneering VIP IT solution in navigation for the blind and visually impaired. The use of this intelligent cane can significantly increase the self- support, mobility and social participation of people with visual limitations.

1.2.2 Thimble

The Thimble [5], as shown in Fig. 1.3, is a new VIP IT concept of multimedia finger glove designed by Erik Hedberg and Zack Bennet, embeds an optical scanner in the glove's fingertip that would translate paper text into Braille messages that are a set of raised bumps or dots which can felt with the finger by VIP. The Thimble would also acts as a location aware connection to the Internet that could deliver news or confirm the person's current location all via Braille messages transmitted through the Thimble's sensor-laced fingertip.

Fig. 1.3 Thimble [5]

1.3 RFID cane for Visual Impairment Person

In the daily life of VIP, the problems such as navigation, positioning and switching on the light still could not be solved completely. Moreover, most of the VIP cannot afford to the expensive price of the technology. The design of the technology should be focused on the price, and the cost should be as low as possible to fit the VIP's financial situation. To this end, the UHF RFID could be a choice to solve the above. Nowadays, the UHF RFID is popular because of its low cost, overcoming the limitation of LOS and wireless connectivity. This project is about to apply the UHF RFID into an indispensable tool of the VIP's cane, which shown in Fig. 1.4.

Fig. 1.4 VIP's cane

To the VIP, a simple and basic control problem is possibly to solve switching on and off the systems or machines. In this project, we are going to apply the principle of the polarization of RFID tag attached to the VIP's cane as simple and cost effective control method. By detecting the RSSI of the tags in different polarization due to cane orientation in VIP posture, relevant control signals are mapped. In other words, with the specified RSSI the reader detected, different functions can be developed.

1.4 Postal Service for VIP

Nowadays, there are different types of postal services for VIP in different countries. In U.S., the postal service allows VIP to send and receive books, recorded material, certain types of equipment and other mail free-of-charge if they are registered at the local post office [6]. In addition, the words "FREE MATTER FOR THE BLIND OR HANDICAPPED" have to be placed at the right top corner of the envelope. In U.K., the similar postal services are being provided, the 1st Class and Air Mail letters, large letters and packets can be sent by VIP for free. However, the VIP who want to send specially prepared items have to registered blind or recognized visually impaired individuals [7]. Although those postal services can make the process of sending and receiving letters more convenient for the VIP, the daily problem of VIP such as writing and reading still exist.

USPS.COM

Fig. 1.5 The logo of the post service in U.S.

Fig. 1.6 The logo of the postal service in U.K.

1.4.1 RFID cane for VIP Postal Service

In this work, a UHF RFID cane is developed to realize the followings as in Fig. 1.6:

1. Cane with RFID tags

   In this project, the tags that are used for the detection of RSSI had been attached on the cane. From section 1.2, it is said that the detection of the RSSI would be the method to define which direction of the cane the user holds.

2. Detector (RFID reader)

   As we have used the RFID to be the detection skill in this project, so the detector should be the RFID reader.

3. Host computer

   As the program had to be run on the computer with the operating system, we need a computer that the Window had been installed.

4. Output

   The output of this application can be any devices supporting the services of post office. In this project, as we have focused on the printing function.

Using the cane with RFID tags, it can act as a remote control via the polarization of the RFID tags. As the identity and the RSSI of the tags can be detected, different functions can be done.

For the VIP, functions such as printing and the voice service can be considered. The printing function means that the printing the stamps, letters that is important to the daily life to the VIP. Moreover, the voice service such as “Voice to text” and “Text to Voice” which can improve the daily life of the VIP.

Besides, when the VIP tourist arrived at a landmark, it can tell them the information of the landmark. Moreover, the post cards can be printed via the printing function.

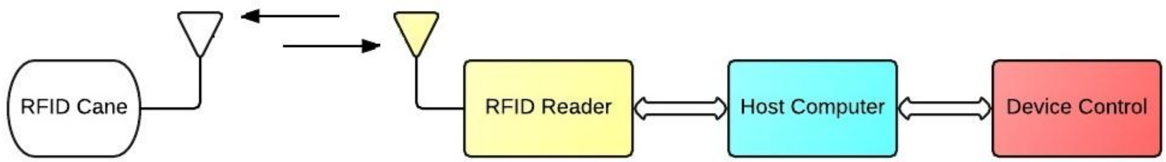


Fig. 1.7 RFID cane for VIP Postal Service

1.4.2 VIP RFID Postal Kiosk

A Kiosk, in Fig. 1.7, means the Electronic tour guide, always acts as an important role for supporting information or services to the people. As it can help provide a convenient daily life to the people, we can see that it had been used in many organizations under the government.

Fig. 1.8 Kiosk

For future RFID postal service, VIP can be benefited from the following functions as shown in Fig. 1.8.

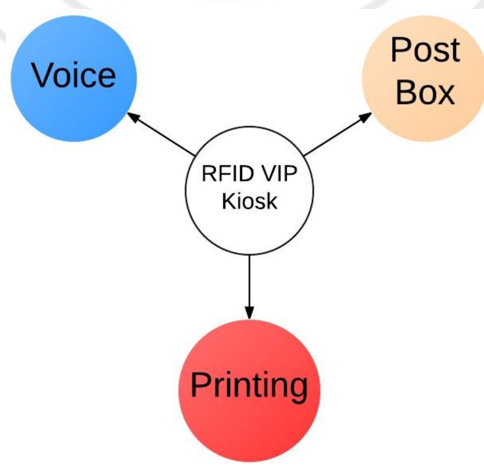


Fig. 1.9 RFID VIP Kiosk

From Fig. 1.8, it shows that the main functions of the Kiosk:

- Voice:

The voice function can act as a voice guide of landmark. To the VIP, it also can act as a speaker for reading the letters in future.

- Post Box:

As the reader in the kiosk can detect the identification of the VIP, the action of receiving letters can be more convenient for the VIP. They just have to bring their cane to the kiosk and get their letters. Moreover, the part of separating and transporting letters from the post office to the post box can be simplified by detecting the identification storing in the tags in future.

- Printing

Writing is still a problem to the VIP so the combination of the "Voice to text" and printing function can help them to solve this problem.

CHAPTER 2 RFID FUNDAMENTALS

Contactless identification for objects in near and far field operation has become a mature technology worldwide. It is indeed Automatic Identification and Data Capture (AIDC) which is about the methods of automatically identifying objects, collecting data about the objects, and entering the data into the information systems. Traditionally, the barcode is one of the most common AIDC technologies since its maturity and economic gain. However, as the limitations of requirements of the line-of-sight (LOS) operation, the Radio Frequency Identification (RFID) using RF technology becomes a more popular technology.

2.1 History of the RFID

It is said that the radio frequency identification (RFID) found implementation in tracking supplies in the late 1980s. However, it can be observed that the roots of RFID technology could be traced back to World War II. The Germans, Japanese, Americans and British were all using radar, which had been discovered in 1935 by Scottish physicist Sir Robert Alexander Watson-Watt, to warn of approaching planes while they were still miles away. The problem was that there was no way to identify which planes belonged to the enemy or which were a country's own pilots returning from a mission.

The Germans discovered that if the pilots rolled their planes when they returned to base, it would change the radio signal reflected back. This method changed the radar on the ground that these were German planes and not Allied aircraft (and this is the first passive RFID system).

Under Watson-Watt, the British developed the first active Identify Friend or Foe (IFF) system. They put a transmitter on each British plane. When it received signals from radar stations on the ground, it began broadcasting a signal back that identified the aircraft as friendly. The RFID system works as same as this basic concept. A signal is sent to a transponder, which reflects back a signal (passive system) or broadcasts a signal (active system). To understand the history of the RFID system briefly, the summary of the development of the RFID is shown in Fig. 2.1.

1940's

- Major WW II development efforts
- RFID invented in 1948

1950's

- Early explorations of FID technology
- Long-range transponder systems for “ID of friend & foe” (IFF) for aircraft

1960's

- The first RFID companies Sensormatic & Checkpoint are founded
- First commercial application Electronic Article Surveillance (EAS) is released to counter theft

1970's

- Very early adopters implement
- RCA & Fairchild publish “Electric ID System”
- NY & NJ Port Authority test electronic toll applications

1980's

- Commercial applications for RFID enter the mainstream
- Applications emerge in transport. Industrial, personal access and animal tagging
- Toll roads world-wide are equipped with RFID

1990's

- Emergence of initial RF open standards
- RFID widely deployed in toll collection, animal, tagging and personal identification
- MIT founds the Auto-ID Center

2000+

- First CPG / Retailer auto-ID pilots launched
- Gillette buys 500 million tags from Alien Tech.
- Wal-Mart. Tersco & the US Department of Defense announce supplier mandates

Fig. 2.1 The history of RFID [8]

2.2 Architecture

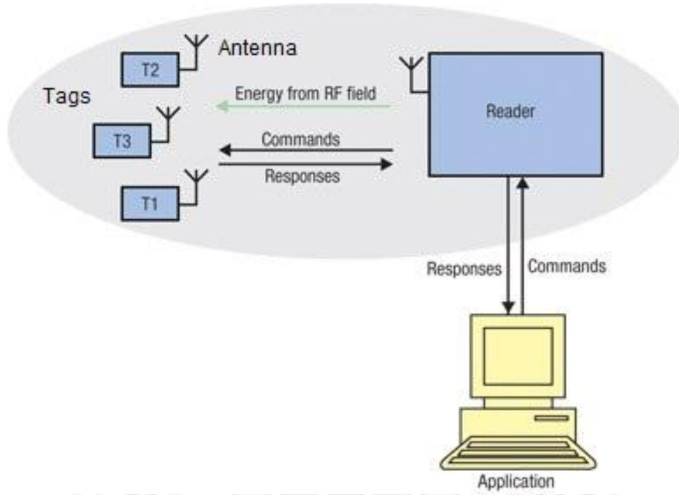


Fig. 2.2 Architecture of a RFID system

RFID systems are made up of three main components shown as in Fig. 2.2, including the RFID tag, the RFID reader and antenna, and the back-end application in host computer. Also, the operation of the RFID system can be divided into three steps with these components:

- The RFID tag, regardless which types of it (Passive, Semi-Passive or Active) will send the data to the RFID reader and antenna via the radio frequency.

- The RFID reader and antenna, which acts as both a transmitter and receiver of radio frequency signals, has a demodulator to extract the returned data and also contains an amplifier to strengthen the signal to the host computer for processing.

- Finally, the back-end applications into the host-computer receives the data from the reader and have a processing, filtering, analysis and generate the data to the back-end users.

2.3 RFID tag

Fig. 2.3 RFID tag

In an RFID system, each object will be labeled with a tag (see Fig. 2.3). A tag generally contains a microchip with some computation and storage capabilities, and a coupling element, such as an antenna coil for communication. A tag can obtain power from the signal received from the reader, or it can have its own internal source of power. The way the tag gets its power generally defines the category of the tag. It can be classified according to three main types according to the application of concern:

- **Passive RFID tags:**

  Passive tags do not have an internal source of power. They draw power from the reader that sends out electromagnetic waves which induce a current in the tag's antenna and powers the microchip's circuit. They are restricted in their read/write range (approximately 5 meters) depend on RF electromagnetic energy from the reader for both power and communication

- **Semi-passive RFID tags:**

  Semi-passive tags use a battery to run the microchip's circuitry but communicate by drawing power from the reader signal.

- **Active RFID tags:**

  Active tags have an internal battery, which are used to run the microchip's circuitry and to broadcast a signal to the reader, thus have a range of approximately 20 meters.

2.4 RFID Reader and Antenna

Fig. 2.4 Examples of RFID readers

RFID readers are generally composed of an RF module, a control unit, and a coupling element to interrogate electronic tags via RF communication. Readers may have better internal storage and processing capabilities, and frequently connect to backend databases. Complex computations, such as all kind of cryptographic operations, may be carried out by RFID readers, as they do not usually have more limitations than those found in modern hand held devices or PDAs. Moreover, for some applications, readers with different form-factors are deployed.

2.5 Back-end Database (Host Computer)

The information provided by tags is usually operated by the back-end database such as server. Also, middle applications are required in the RFID transmission. A major problem for companies seeking to implement the RFID solution is lack of sufficient middleware to link RFID systems and company’s applications. Middleware software or applications are needed to manage the flow of data from readers and send the data to the back-end management systems. RFID middleware in the host computer assists with the following:

- Receiving data from readers;
- Filtering the data and feeds to application software;
- Generating object movement notifications;
- Monitoring tags and readers network performance;
- Capturing the history of the processing.
- Analyzing the data of the tag for application tuning and optimization.
- Readers with different form-factors are deployed.

2.6 Standardization

According to the development of RFID, there are the two standards.

2.6.1 The International Organization for Standardization (ISO)

It is the world's leading developer of international standards. ISO technical standards specify the requirements for products, services, processes, materials, and systems. ISO has also developed standards for good(s) conformity assessment managerial, and organizational practices. Also, it defines standards for all the RFID frequencies:

Low Frequency	(LF)	(< 135 kHz)
High Frequency	(HF)	(13.56 MHz)
Ultra-High Frequency	(UHF)	(860 – 960 MHz)
Microwave Frequency	(MW)	(2.4 and 5.8 GHz)

Moreover, the ISO standard series of RFID is shown as Table 2.1 and the coverage of the ISO is shown in Fig. 2.5.

2.6.2 The EPC global

It has also contributed to RFID standardization. EPC is a joint venture between the EAN International and the Uniform Code Council (UCC). It was chartered to establish and support the Electronic Product Code (EPC) Network as the global specification and leading to the global worldwide standard (ISO) for immediate, automatic and accurate identification of any item in the supply chain, and has become the major organization for the development of RFID specifications and the coverage is shown in Fig.2.6.

Fig. 2.5 The coverage of The International Organization for Standardization (ISO)

Fig. 2.6 The coverage of The EPC global

As a comparison, there are some differences between the above two standards in several aspects shown in Table 2.2, which include: physical, data link and application layers. In contrast to the generic ISO RFID standards, EPC global standards are more specific in UHF domain and target for low-cost tag.

Standard	Description
11784	Radio Frequency Identification for animals- Code structure
11785	Radio frequency identification for animals- Technical concept
14443	Identification cards – contactless integrated circuit cards - Proximity cards
15693	Identification cards – contactless integrated circuit cards - Vicinity cards
15961	Radio frequency identification for item management - Data Protocol : Application interface
15962	Radio frequency identification for item management - Data
18000-1	Radio frequency identification for item management - Part 1 : Reference architecture and definition of parameters to be standardized
18000-2	Radio frequency identification for item management - Part 2 : Parameters for air interface communications below 135 kHz
18000-3	Radio frequency identification for item management - Part 3 : Parameters for air interface communications below 13.56 MHz
18000-4	Radio frequency identification for item management - Part 4 : Parameters for air interface communications below 2.45 GHz
18000-5	Radio frequency identification for item management - Part 5 : Parameters for air interface communications below 5.8 GHz
18000-6	Radio frequency identification for item management - Part 6 : Parameters for air interface communications below 860 MHz to 960 MHz
18000-7	Radio frequency identification for item management - Part 7 : Parameters for active air interface communications below 433 MHz

Table 2.1 The important ISO standards for RFID technology [8]

Characteristics	ISO	EPC
Membership	Driven by RFID manufacturers	Driven by large users (retailers and suppliers)
Resources	-Volunteers -Internal consultants from large companies -External consultants that represent different smaller companies	-Full-time staffs -Academics (MIT) -Universal Currency: a trade association funded by industry members
Process	Slow & bureaucratic process	Fast process
Approach	High-level & generic approach, focusing not on the data itself, but on how to access it	Specific, focusing on the data itself
Air interface	Cover the entire range of frequency	Mainly on UHF
Chips	Bigger and smarter chips (i.e. expensive)	Smaller chips (Cheap enough to make economic sense for the packaged good industry)

Table 2.2 Comparisons between the ISO and EPC Global [8]

2.7 Ultra High Frequency RFID (UHF RFID)

RFID system is an integrated technology of wireless communication, computer science, database management and integrated circuits technology. Because of the first functional passive RFID systems, with a range of several meters, RFID has a large growth.

	LF	HF	UHF
Frequency range	<135 kHz	13.56 MHz	860 – 960 MHz
Standards specification	ISO/IEC 18000-2	ISO/IEC 18000-3 ISO 15693 ISO 14443(A/B)	ISO/IEC 18000-6
Read range	< 0.5m	~ 1m	~ 5m
General characteristics	-Larger antennas resulting in higher tag cost. -Least Susceptible to performance degradations from metals and liquids	-Less expensive than LF tags -Best suited for applications that do not require long range reading of high number of tags	-Have the potential to be cheaper than LF or HF tags -Good for reading multiple tags at long range -More affected than LF and HF by performance degradations from metals and liquids
Tag power source	Mainly passive using inductive coupling (near field)	Mainly passive using inductive coupling (near field)	Active and passive tags using E-field back scatter the far field
Typical applications	Access Control, Animal tagging, Vehicle immobilizers	Smart cards, Access Control, Payment, IS Item level tagging, baggage control, Biometrics, Libraries, Transport	Supply Chain, pallet and Box tagging, Baggage Handling, and electronic toll collection
Notes	Larger installed base due to mature technology. However will be overtaken by higher frequency technology	Currently the most widely available high frequency world-wide due to the adoption of smart cards in transportation	Different frequencies and power allocated by different countries
Multiple tag read rate	Slower ←	→	Faster
Ability to read near metal or wet surfaces	Better ←	→	Worse
Passive tag size	Larger ←	→	Smaller

Table 2.3 The characteristics of the LF RFID, HF RFID and UHF RFID [8]

Actually, the UHF RFID system can be said that it owns the advantages of higher accuracy, improved sensitivity, longer read/write range and multiple tag detection, compared with its counterparts in Low Frequency (LF)/ High Frequency (HF). To understand whether LF, HF or UHF has the best performance for meeting different goals, the comparison of them is shown below.

As shown in Table 2.3, we can observe that the communication range of UHF is longer than the LF/HF and the passive tag size is smaller than others. It shows that UHF is more suitable for different applications. Moreover, the development of price of UHF would have a potential to be cheaper than the LF and HF, which reach to the important point 'low price'. In this project, as we have to fulfill the need of the VIP, the tag should be chosen with the type of 'passive' as the supply of the tag is one of the point to make the RFID cane become cheaper.

2.7.1 Basic Operation

As illustrated in the Fig. 2.8, the basic structure of a general UHF RFID system consists of

(i) a reader or interrogator, which interrogates a signal to a UHF RFID tags (shown in Fig. 2.7), which is to be identified;

(ii) a UHF RFID tag or transponder, which is a small and mobile "transponder" that is attached to objects that contains the identification message to be decoded by the reader; Tags could only be accessed within the interrogation zone of the reader;

(iii) a reader-attached antenna and the system operates as follows: Signals are broadcasted by the reader via its antenna. The tag receives the signals and responds either by reader or writing the data or by replying with other signal that containing some data, such as an identity code or a result of measurement. Also, the tag may rebroadcast the original signal received from the reader with a predetermined time delay. Signal processing is mostly be completely by a host computer which connects to the reader and the tags' identities may also be displayed or transmitted to the Internet or local computer network which is for the real time monitoring and tracking.

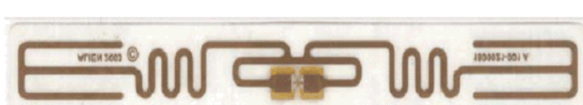


Fig. 2.7 A UHF RFID Tag

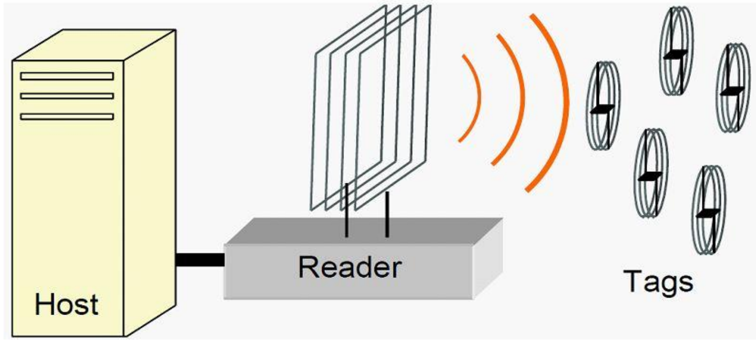


Fig. 2.8 A basic architecture of the RFID system

A compatible RFID system should be designed and implemented based on standard such as international organization for standardization (ISO) or the electronic product code (EPC) global and European telecommunications standard institute (ETSI). In order to design a compatible RFID system, the communication protocols and the standards of the RFID have to be specified. The following standards are relatively popular ISO (International organization of standardization) standards, like ISO 14443, the identification cards - contactless integrated circuit cards – Proximity cards; ISO 15693, the identification cards - contactless integrated circuit cards – Vicinity cards; ISO 18000, etc., which feature the application of RFID globally.

2.7.2 Performance of UHF RFID tag

The performance of the UHF RFID tag can be affected with different cases, they are the tag orientation, deployment environment and the nature of the object on which the tag is placed.

2.7.2.1 Sensitivity to tag orientation

The orientations of the tag and the reader significantly affect the performance of UHF RFID tag. Fig. 2.9 shows the effect that the tag orientation has on the read performance even when the tag is within the reader range of the reader antenna. In order to know whether the tag orientation will affect the tag or not, the experiment [9] have been used. The experiments are performed in an anechoic chamber with the similar setup as present above. In this experiment, the reader is fixed at the position (x,y,z) = (0,0,0) and tag is moved in 50 cm steps in y-direction. Measurements are repeated three times: a tag was oriented differently relative to the orientation of the reader antenna each time. Read rates are recorded in the same way and shown in Fig. 2.9. From Fig. 2.9, it is obvious that the reader range drops significantly when the orientation becomes less favorable for the tag since the tag is not able to collect enough energy to turn on the

IC. Moreover, Fig. 2.9 shows that the read rates depend on the relative orientation of the tag and reader antennas and on the distance between tag and reader.

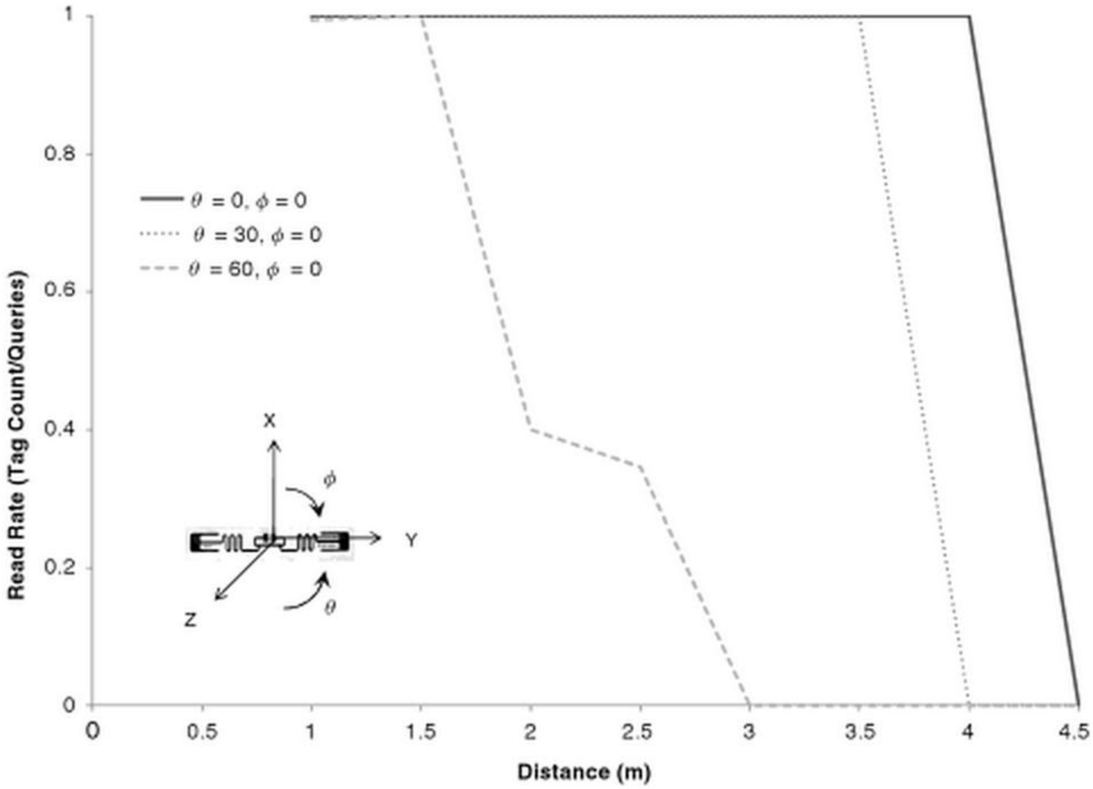


Fig. 2.9 The rate of reading for a single tag with different orientations [9]

2.7.2.2 Sensitivity to deployment environment

Changing the environment, the performance of a practical system will be affected. Similar as any other wireless system, the nature of the environment affected the multipath and fading properties of the channel. Moreover, this effect is even more pronounced in RFID systems due to the passive nature of the tag operation and the low signal to noise ratio (SNR) of the weak backscatter signal. In order to check whether the effect from the environment is existed, the same experiment [9] in section 2.7.2.1 was performed again in the significantly cluttered environment of a normal computer lab room (dimensions of lab are: length 1000 cm, width 600 cm and height 400 cm). Fig. 2.10 shows the read rate performance in the cluttered environment of a computer lab. As we can see, the deployment environment hampers the performance of the system and also introduced some blind spots/null spots due to multipath interfaces and channel fading.

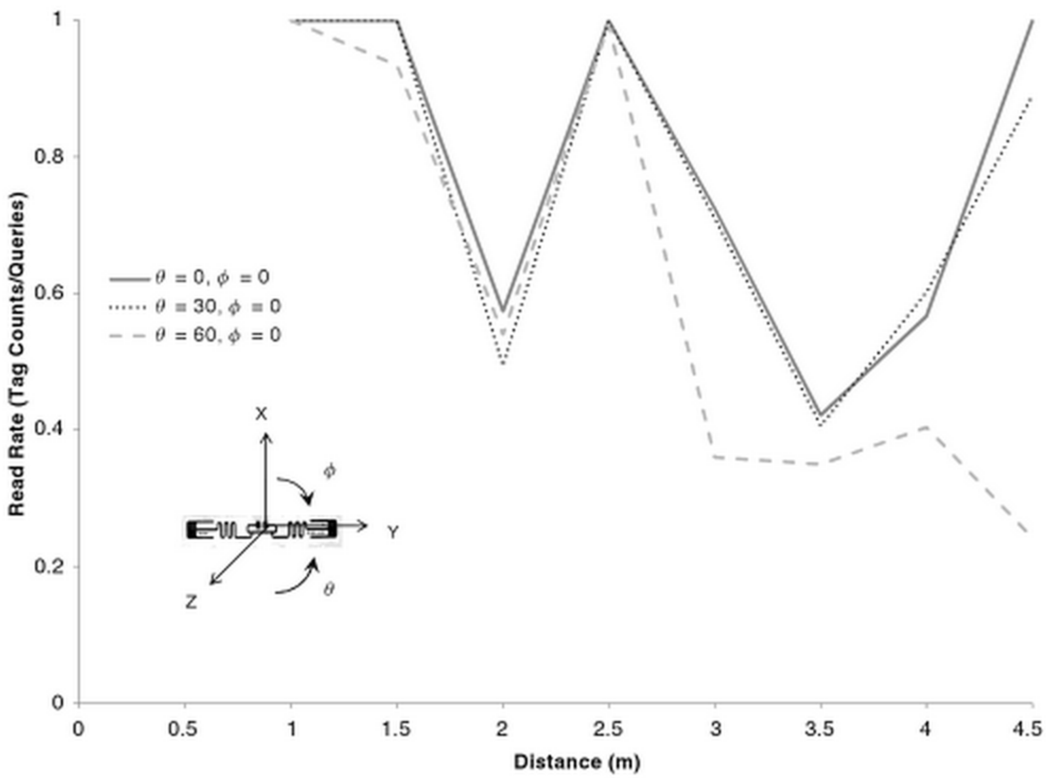


Fig. 2.10 The rate of reading for a single tag with different orientations in a lab room [9]

2.7.2.3 Sensitivity to the material of the object on which the tag is placed

From section 2.7, it is known that UHF RFID system performance will be much affected than LF RFID and HF RFID for metals and liquids. These materials not only attenuate the signal when they are placed between the tag and the reader, but also result in detuning of the tag antenna. Detuning occurs if the materials are in close proximity to the tag. The effect of metal and water on read range and read accuracy was analyzed in several papers [10]. The ranges of reading were reduced up to three times in proximity of water and metal in comparison with the range in free space.

CHAPTER 3 POSTURE EFFECT ON RFID TAG DETECTION

Polarization is one of the fundamental characteristics of any antenna. It is an effect of a wave that can oscillate with a number of orientation. The electromagnetic waves such as light exhibit polarization, and the other types of wave such as gravitational waves. However, the sound waves in gas or liquid do not exhibit the polarization since the oscillation always in the direction the wave travels.

3.1 Antenna Polarization of RFID Tag

In an electromagnetic wave, both of the electric field and magnetic field are oscillating but with the different directions. The electric and magnetic fields are perpendicular to the wave's direction of travel. The oscillation of these fields maybe in a single direction (linear polarization) or it may rotate at the circular or elliptical polarization. The direction of the fields' rotation, and thus the specified polarization, may be in the direction of clockwise or counter clockwise.

3.1.1 Linear Polarization

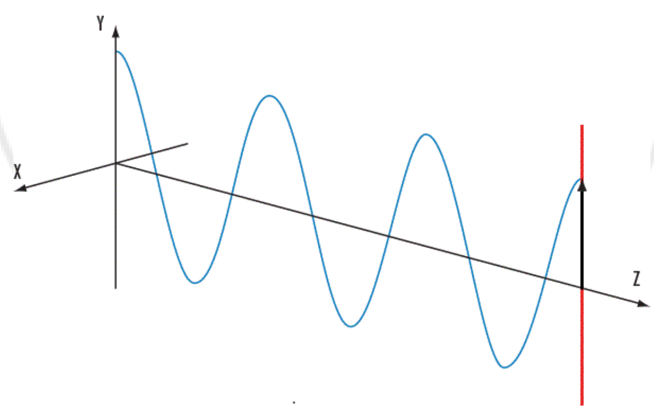


Fig. 3.1 The wave of the linear polarization [11]

A plane electromagnetic (EM) wave is travelling with a single direction such as the wave shown in Fig. 3.1 and there is no field variation in the two orthogonal directions. In this case, the electric field and the magnetic field are perpendicular to each other and face to the direction the plane wave which is propagating. For instance, consider the single frequency E-field in the equation (3.1), the field is traveling in the +z-direction, the E-field is oriented in the +x-direction, and the magnetic field is in the +y-direction.

$$E = \cos[2\pi f\left(t - \frac{z}{c}\right)]\hat{x} \tag{3.1}$$

In the equation (3.1), $\hat{x}$ is a unit vector (that mean a vector with a length of one), which shows that the E-field "points" in the x-direction. The planes of the wave is shown graphically in Fig. 3.2. Moreover, we can know that the meaning of the “Polarization” is that the E-field traces out while propagating by considering the E-field at (x, y, z) = (0, 0, 0) as a function of time described by equation (3.1). The amplitude of the field is plotted in Fig. 3.3 with several times and it is oscillating with the frequency (f).

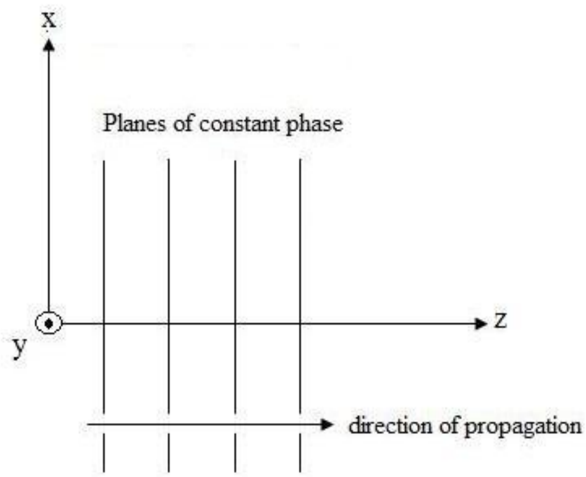


Fig. 3.2 E-field travelling in +z-direction [12]

We can observe at the origin, the E-field oscillates backward and forward in magnitude, it always directed along the x-axis. As the E-field stays along a single line, it would be said to be linearly polarized. In addition, if the x-axis was parallel to the ground, it could also be described as "horizontally polarized". Inversely, if it was oriented along the y-axis, this wave would be said to be "vertically polarized".

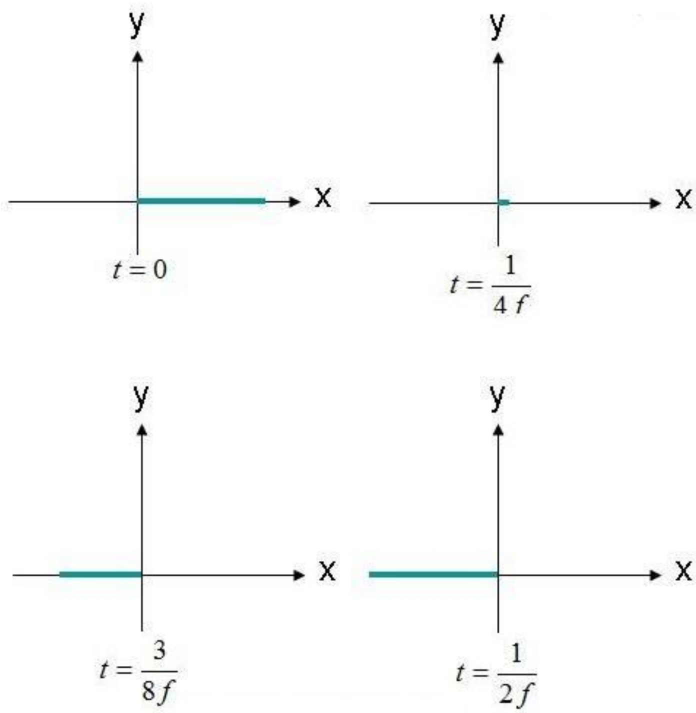


Fig. 3.3 Change of E-field at (x, y, z) = (0, 0, 0) with different times [12]

Additionally, a linearly polarized wave does not need to be along the horizontal or vertical axis. As an example, a wave with an E-field shown in Fig. 3.4 would also be linearly polarized.

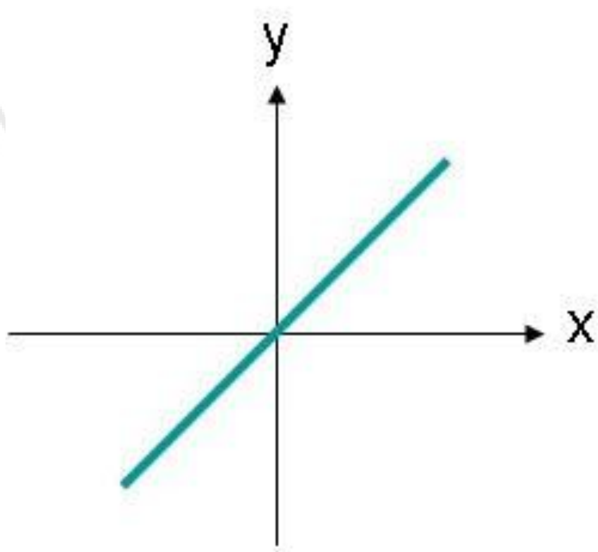


Fig. 3.4 A E-field amplitude of a linearly polarized wave [12]

3.1.2 Circular Polarization

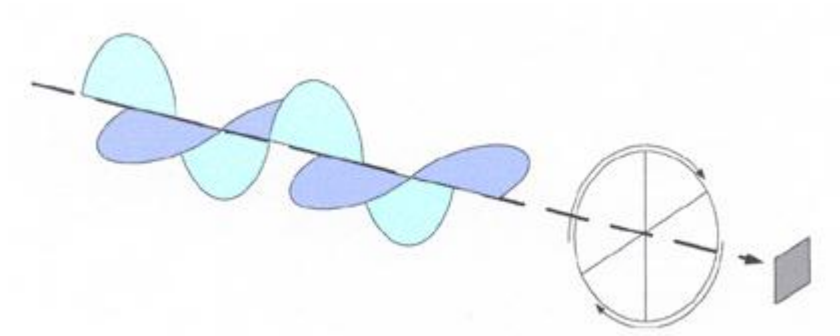


Fig. 3.5 The wave of the circular polarization [13]

The E-field of a plane wave of the circular polarization is shown in Fig.3.5 and its equation is:

$$E = \cos\left[2\pi f\left(t - \frac{z}{c}\right)\right]\hat{x} + \sin\left[2\pi f\left(t - \frac{z}{c}\right)\right]\hat{y} \tag{3.2}$$

In this situation, the x- and y- components are 90 degrees out of phase. If the field is observed at (x,y,z)=(0,0,0) again as Fig.3.3, the plot of the E-field with several times are shown in Fig. 3.6.

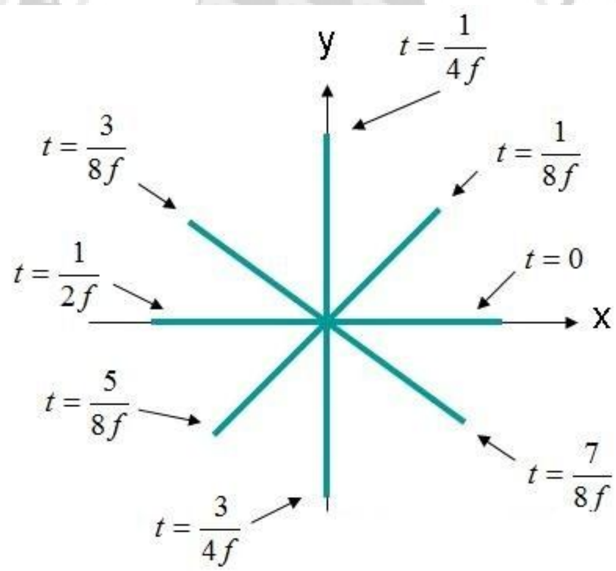


Fig. 3.6 The Change of E-field at (x, y, z) = (0, 0, 0) with different times [12]

The E-field in Fig. 3.6 rotates in a circle. This type of field is described as a circularly polarized wave. If we have to make a circularly polarization, there are several criteria must be met: The E-field must have two perpendicular components.

- The E-field's perpendicular components must have equal magnitude.
- The perpendicular components must be 90 degrees out of phase.

If the wave in Fig. 3.6 is travelling out of the screen, it is rotating in the counter-clockwise direction and could said to be "Right Hand Circularly Polarized". Inversely, if it was rotating in the clockwise direction, the field would be "Left Hand Circularly Polarized".

<u>3.1.3 Elliptical Polarization</u>

If the E-field has two perpendicular components that are out of phase by 90 degrees but without the equal magnitude, the field is so called the Elliptically Polarized. Observe the plane wave travelling in the +z-direction, with E-field described by equation (3.3):

$$E = \cos\left[2\pi f\left(t-\frac{z}{c}\right)\right]\hat{x} + 0.3\sin\left[2\pi f\left(t-\frac{z}{c}\right)\right]\hat{y} \quad (3.3)$$

The locus of points of the E-field vector would assume is given in Fig. 3.7.

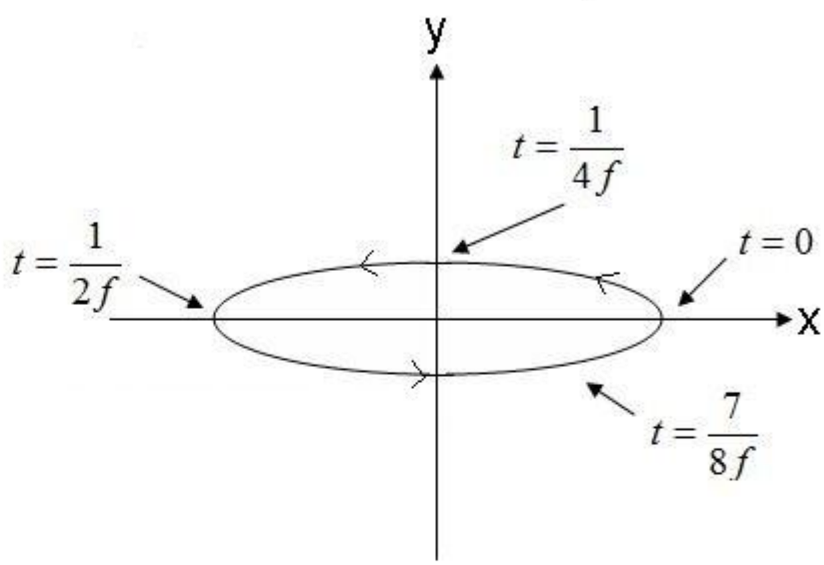


Fig. 3.7 Change of E-field at (x, y, z) = (0, 0, 0) with different times [12]

As shown in Fig. 3.7, it travels in the counter-clockwise direction, and if travelling out of the screen would be "Right Hand Elliptically Polarized". Inversely, if the E-field vector was rotating in the opposite direction, the field would be "Left Hand Elliptically Polarized".

3.2 Polarization Loss Factor

In general, the polarization of the receiving antenna will not be the same as the polarization of the incident wave from the transmitting antenna. This is commonly called as polarization mismatch. The amount of the power extracted by the antenna from the incoming signal will not be maximum because of the polarization loss. Here, we assume that the electric field of the incoming wave can be written as:

$$\overrightarrow{E_\iota} = \widehat{\rho_W} E_i \tag{3.4}$$

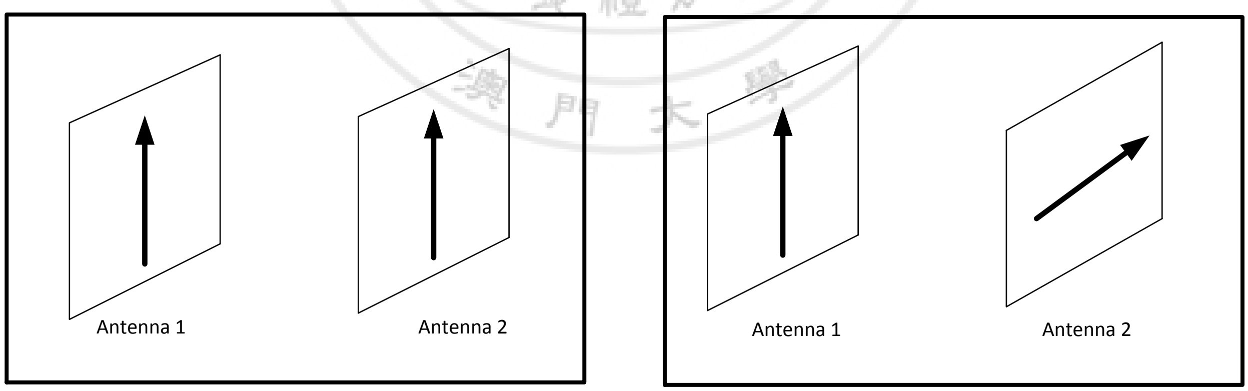
Where $\widehat{\rho_W}$ is the unit vector of the incident wave, and the polarization of the electric field of the receiving antenna can be expressed as:

$$\overrightarrow{E_\alpha} = \widehat{\rho_\alpha} E_\alpha \tag{3.5}$$

Where $\widehat{\rho_\alpha}$ is its unit vector, the polarization loss can be taken into account by introducing a Polarization Loss Factor (PLF). Based on the polarization of the antenna in its transmitting mode, it can be defined as:

$$\text{PLA} = |\widehat{\rho_W} \cdot \widehat{\rho_\alpha}|^2 = |\cos\varphi_p|^2 \tag{3.6}$$

Where $\varphi_p$is the angle between the two unit vectors. It means that if the direction of the field vector of the incoming wave is the same as the receiving field vector, it is called matched completely and the antenna can extract maximum power from the incoming wave, as shown in Fig. 3.8(a). While if the direction of the field vector of the incoming wave is orthogonal to the receiving field vector, it is called mismatched, then no power from the incoming wave can be extracted, as shown in Fig. 3.8(b). Based on this idea, when the cane attached UHF RFID tag exhibits different posture, i.e., the horizontal and the vertical posture, different power can be extracted, and this can be used as a control function.



(a) (b)

Fig. 3.8 The match of polarization

3.3 Signal Control using Posture effect on RFID Tag

When a RFID tag is attached to a VIP's cane, the above polarization can be used to characterize VIP's posture in order to implement relevant control signal. According to common UHF RFID tag, its polarization is linear polarization in fact. From Fig. 3.9, we can observe that the position of the tag which is attached on the lower panel of hand rail of cane. And the process of the signal controlling is illustrated in Fig. 3.10 to Fig. 3.12.

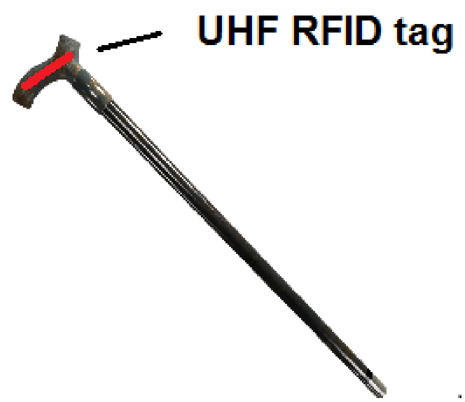


Fig. 3.9 The cane with the UHF tag

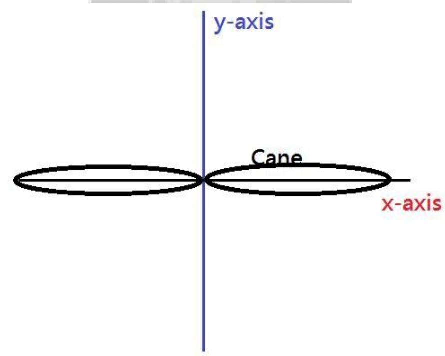


Fig. 3.10 The cane in horizontal position

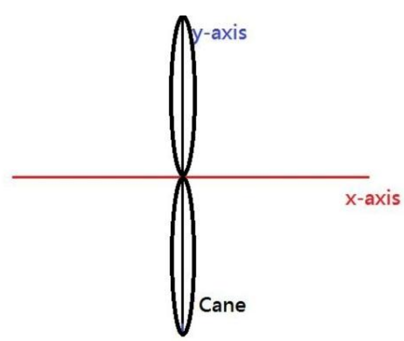


Fig. 3.11 The cane in vertical position

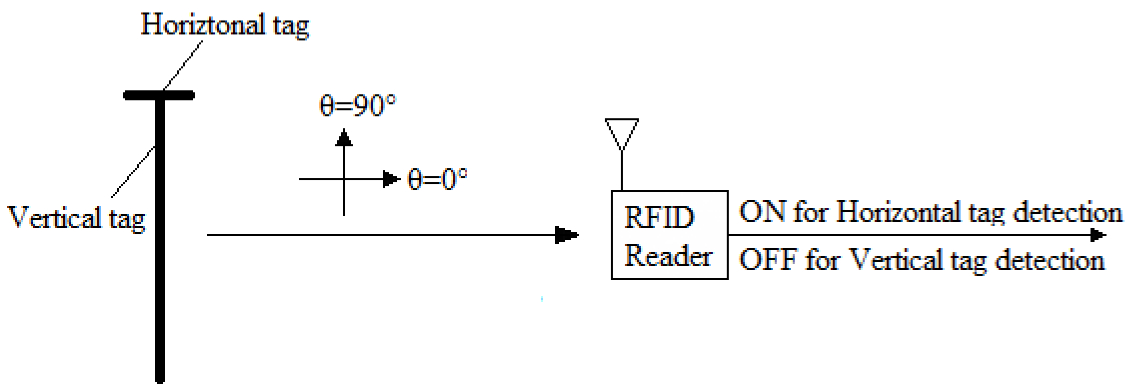


Fig. 3.12 Two-tag RFID VIP's cane Posture Control

As in Fig. 3.10 and Fig. 3.11, it refers to relevant UHF RFID tag polarization when tag is placed in horizontal and vertical position. Consider two tags are attached to the VIP can as shown in Fig. 3.12, it is obvious that only one tag is detected if the cane is rotated in 0° or 90° with respect to reference angle of θ. By the principle of the polarization, we can observe that the RSSI will be changed depend on the angle of the cane in horizontal (0°) and vertical (90°). If we put the cane in vertical, with the communication between the tags and the readers, the host computer can do the processing to calculate the RSSI of the tags. When the RSSI of the tags fulfil the range of the RSSI needed, the switching ON function will be yielded. Inversely, if it fulfils the range of the RSSI needed in 90° phase difference, the switching OFF function will be yielded.

CHAPTER 4 RFID ENABLED CONTROL MECHANISM

4.1 Introduction

The generalized RFID control for VIP is implemented as follows:

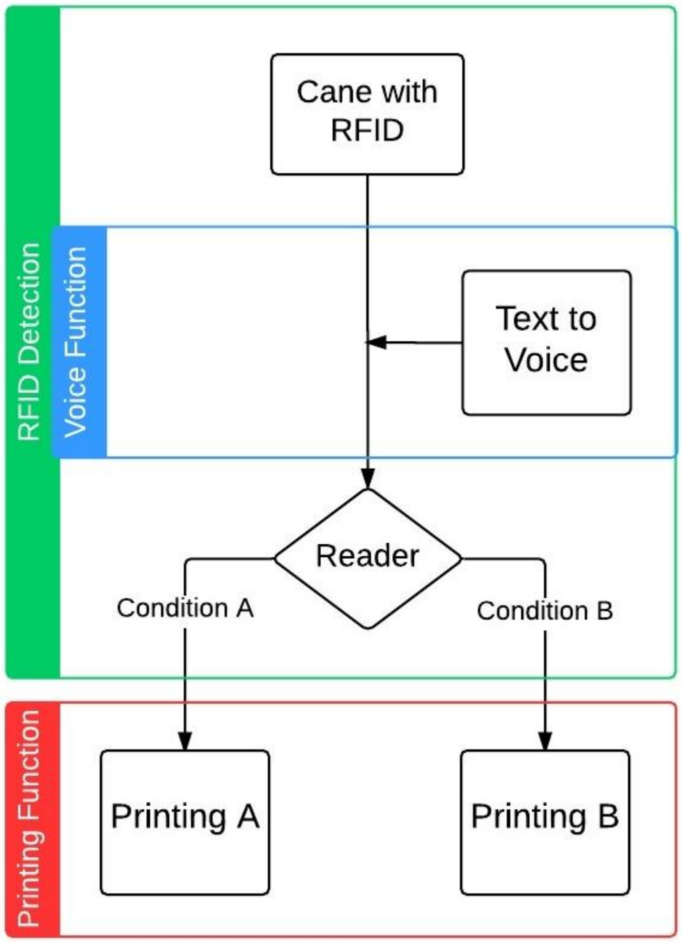


Fig. 4.1 The idea of the flow chart in this project

The RFID cane detection: According to the principle of RFID, the detector stands for the antenna and the serial board of the RFID. By analysis of the data from the detection, the different functions can be done due to different conditions.

Text to voice: This is a function which is coded by the specified language (C#)

Printing: This is a function which is coded by the specified language (C#)

4.2 Element of RFID ENABLED CONTROL MECHANISM

4.2.1 The cane

Firstly, the choice of the cane must be appropriate and must be followed the standard of ISO 23599:2012 [Appendix A]. Since the target of the user in this project is VIP, so the most important property of it is the mobility and the cost. We can see that the cane can be adjusted its shape into smaller one shown in Fig.4.2. Because of its shape, it becomes more mobility to the VIP. If the VIP wants to make it to the original shape, it's easy to make it by just release.

Fig. 4.2 The cane

On other hand, the second point in this project is the cost of it. In this case, the VIP can afford to it because it costs only MOP 120. Actually, changing the model of the cane can reduce the cost. As we have to mention the balance between the cost and the mobility, the changing of the model cannot work in this project. If we change the model to the normal one, it cannot fulfil the mobility to the VIP.

Besides the cost and the mobility, we know that the material will affect the effectiveness of the tags from session 2, the solution of reducing the effectiveness of the tags is to install a layer between the tags and the cane.

4.2.2 The Tags

From the comparison with Low Frequency (LF), High Frequency (HF) and Ultra High Frequency (UHF) in section 2.7, we can know that the UHF is the best choice of the RFID tags in this project, but there are several conditions have to be concerned, they are:

- The typical read range
- Multiple tag read rate
- Cost
- Size of the tags

As the idea of this project is the controller, the typical read range cannot be too strong at all. In this case, the read range of the UHF is around five meters which reach the target we need. To the multiple tag read rate of it, it is said that the UHF is faster than others so that it will have the best performance we want. After that, the two relatively important points are the cost and the size of the tags. To the cost of it, as the UHF have potential to be cheaper than the LF and HF tags, we think that the development of it is suitable for us to use it. Moreover, we cannot have a large size of tags in this project because they have to attach to the cane. As we can see, the UHF tags has the smallest size in the comparison of the size of tags. Conclusively, the UHF has the best performance in these fields so that the UPM UHF tag [Appendix C] will be chosen in this project and the shape of it is shown in Fig. 4.3.

Fig. 4.3 The UPM UHF tag [Appendix C]

<u>4.2.3 The RFID reader</u>

The reader we will use in this project is the R-2000 Serial M-2800 [Appendix B] (shown in Fig. 4.4) and the advantages of it is that it is easy to integrate, low system cost and small footprint.

Fig. 4.4 The R-2000 Serial M-2800

<u>4.2.4 The Host Computer</u>

The host computer we will use in this project is Lenovo notebook L440, the brand of Lenovo. Running the program of C# [Appendix D] is the requirement of it in this project. Also, the LAN port and the USB port is a must because the connection between the reader and the computer is the LAN port.

Fig. 4.5 The host computer

4.3 The Operation

The main idea of this project is to make the VIP to have single wireless control by their posture. As we can see, two tags are attached to the cane as shown in Fig. 4.6. By applying the operating process shown in Fig. 4.1, the cane can act as a controller.

Fig. 4.6 Positions of the UHF tags

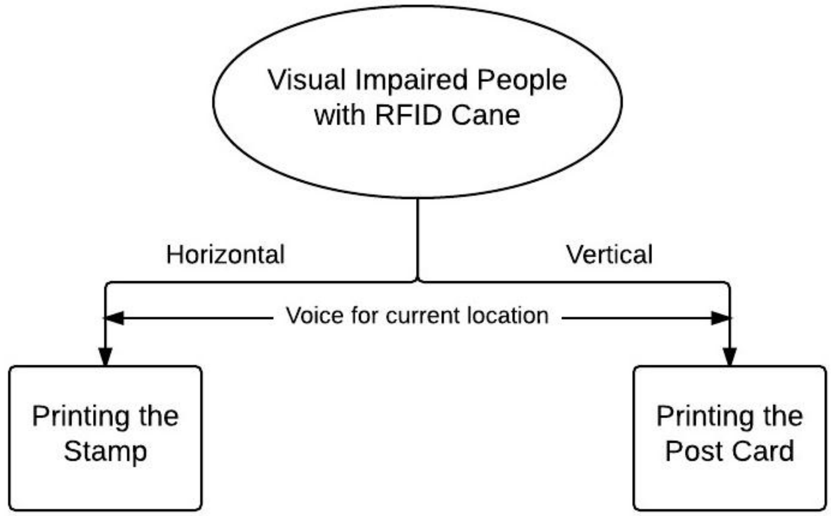


Fig. 4.7 The flow chart of the whole system

To provide a convenient postal service for VI tourist, the "Text to Voice" function and printing are integrated to the system. The former is for guiding them to know the place they are located or getting more information of the place. The latter is for providing the postal service such as printing the stamp and post card. According to the RFID cane's posture held by the VIP, the steps of the operations can be described in following:

- Changing the position of the cane in a specific distance between the cane and the reader. The distance should be around one to two meter which will be explained in detail in the experiment part;
- Voice for current location such as the sentence, "You are now in E11-FST Building in Hengqin Campus", is performed;
- The antenna can detect the tags by applying the principle of the RFID;
- As the antenna is connected to the host computer, the RSSI of the tags can be measured via the program;
- Because the range of the RSSI of the "horizontal" and "vertical" had been set in the program so the position of the cane can be detected;
- Performing the printing function.

As we can see, the controlling with RFID can be done via the detection of the RSSI. It shows that more functions and improvement of the accuracy would be a challenge in the future. Furthermore, the obstacle between the reader and the tags and the material of the cane which will affect the effectiveness will be tested in next chapter.

CHAPTER 5 EXPERIMENTAL RESULTS

This chapter is going to find out which conditions will have a best performance of RFID cane to this project by three experiments. The differences between the experiments are materials of the cane and the obstacle between the tag and reader. The materials we used in the first experiment are the iron, wood, copper, plastic and aluminium. The obstacles we tested in the second experiment are the air, copper and plastic.

5.1 Experimental Setup

In the experiments, our goal is to measure the RSSI of two tags via the reader. The setup of experiment is shown as Fig. 5.1 and the meanings of the symbols are explained as below:

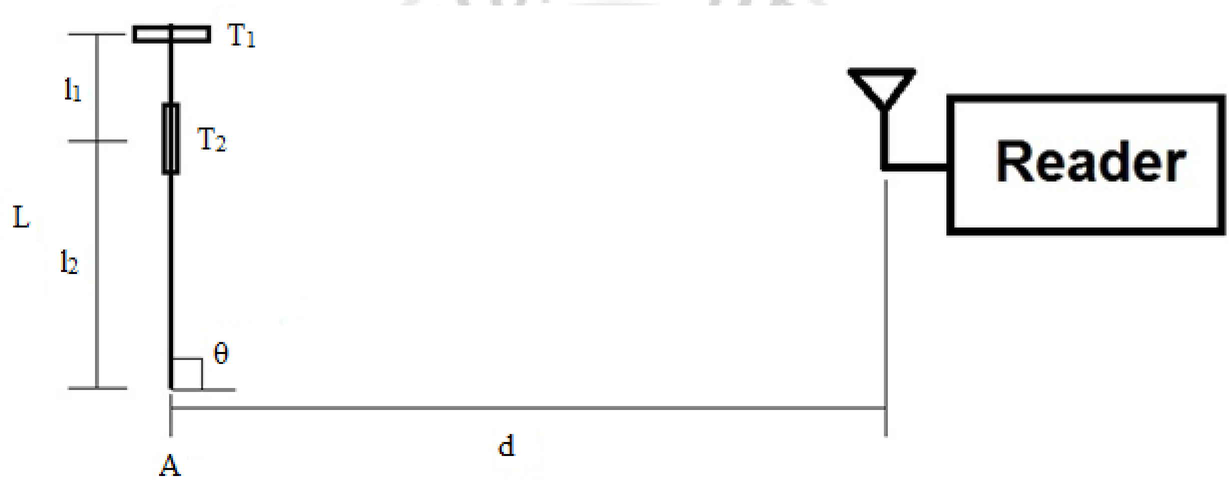


Fig. 5.1 The setup of the experiment

T_1= UHF RFID (Horizontal)

T_2= UHF RFID (Vertical)

L = Length of the cane

l_1 = Length between the Tag 1 and Tag 2

l_2 = Length between the Tag 2 and the ground

θ = Angle of the cane to the ground

d = Distance between the cane and the reader

In this experiment, the cane which we used is shown in the last chapter. Also, the host computer used in this computer is the Lenovo notebook L440 and the reader is the Indy R2000 Module Series specification. Moreover, the connection between the reader and the host computer is the category 5 cable (LAN cable). The program we use to detect the RSSI of the tags is “UHFDemo” and the screenshot of it is shown in Fig. 5.2. and Fig. 5.3. The Fig. 5.2 shows the “Basic Setup” of the reader and the host computer. By changing the Reader IP Address of the host computer to “192.168.0.178” and the Port to “4001” in Part A, we can connect the host computer and reader via the cable. After pressing the “Connect” button, the notice of “Reader corrected” will be shown in the panel at the bottom of the program (Part B). Then, we can move up to the “RF Setup”.

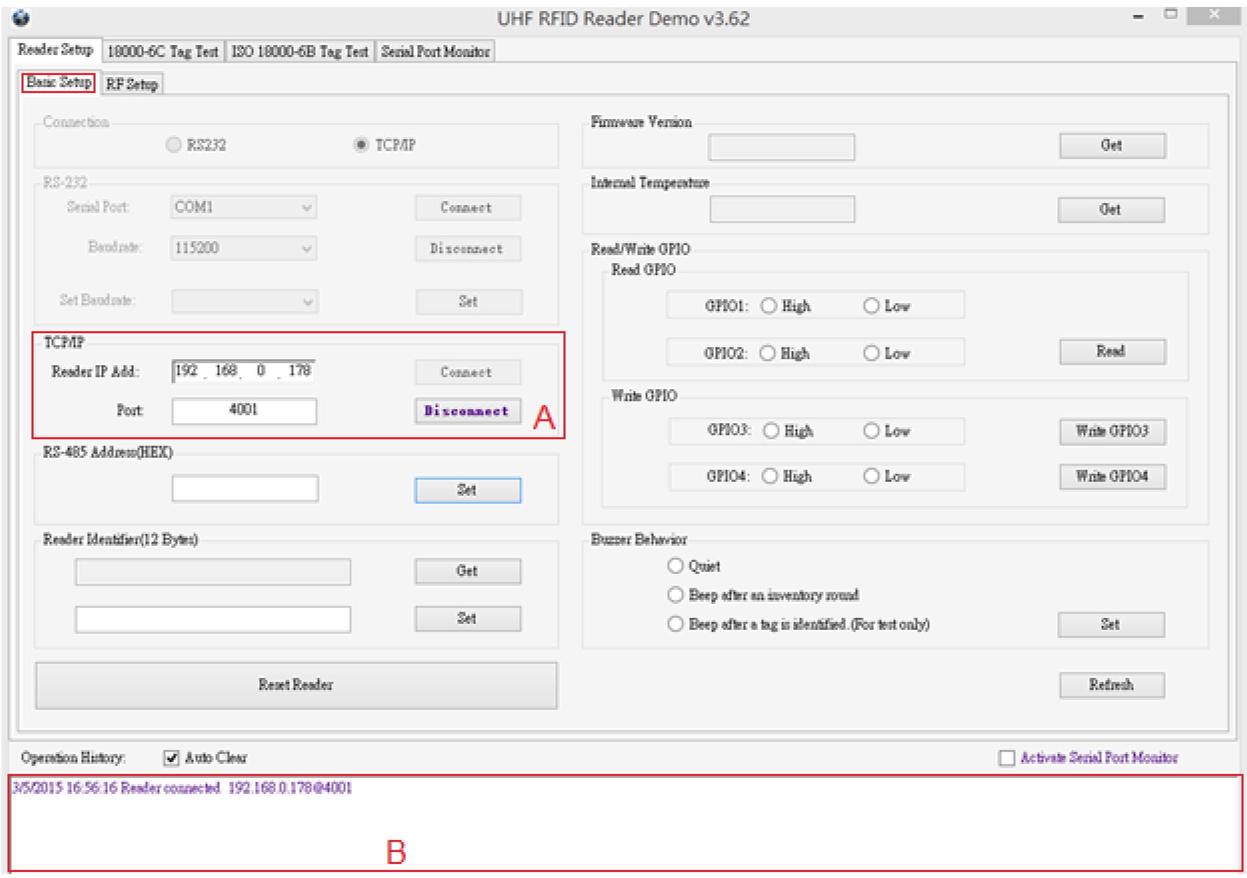


Fig. 5.2 Basic Setup of the UHFDemo

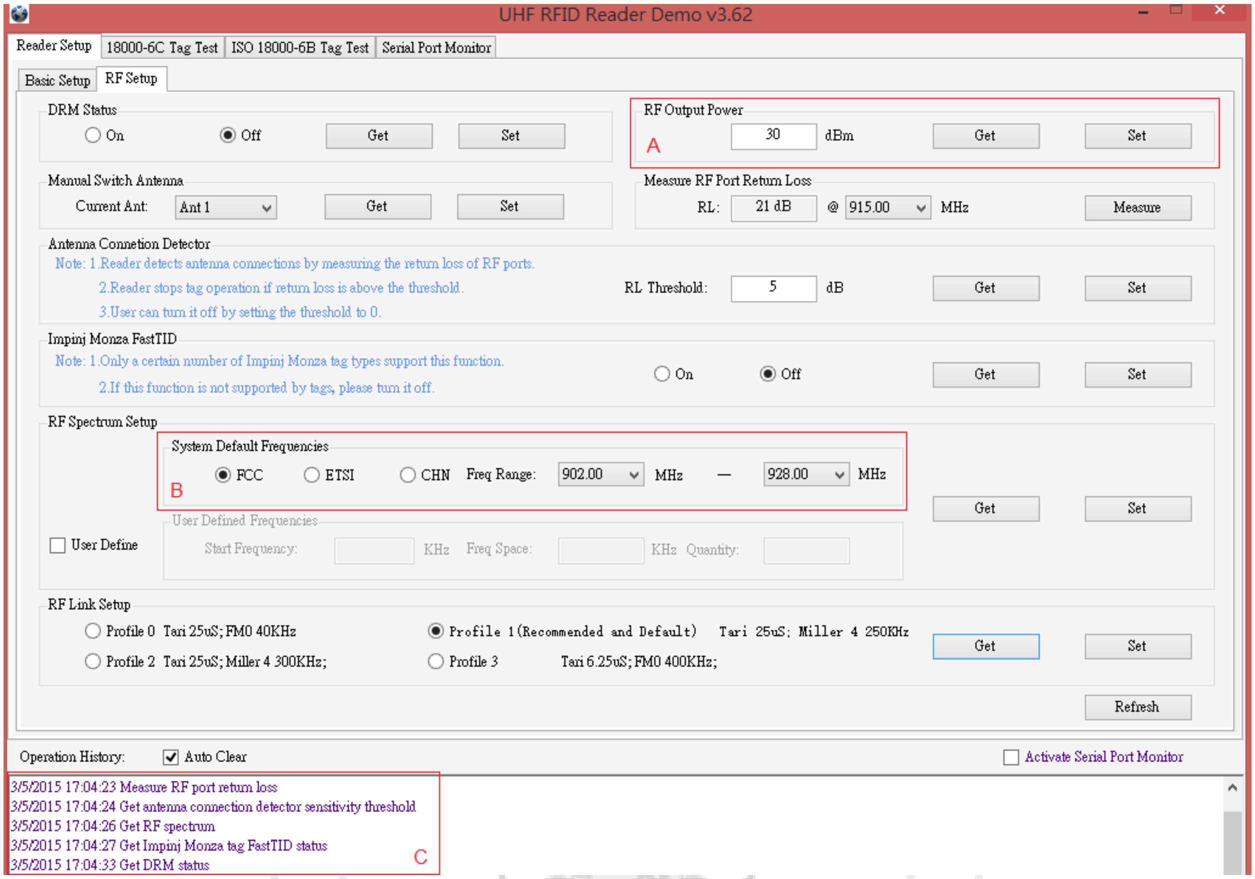


Fig. 5.3 RF Setup of the UHFDemo

In Part A, we have to set the output power of radio frequency to 30 dBm which means that it will send out the output power to tag per time. In Part B, the frequency range which the reader supports is 865 MHz to 868 MHz and 902 MHz to 928 MHz. As we have to detect the UHF RFID tag in this project so we choose the latter. After that, the notice is also in the panel at the bottom of the program as in Part C. Therefore, the setup of the program is completed.

5.2 Testing Result

5.2.1 RSSI of RFID tag in cane made of different materials

Material	Iron		Copper		Plastic		Wood		Aluminium	
d (cm)	RSSI of T_1 (dBm)	RSSI of T_2 (dBm)	RSSI of T_1 (dBm)	RSSI of T_2 (dBm)	RSSI of T_1 (dBm)	RSSI of T_2 (dBm)	RSSI of T_1 (dBm)	RSSI of T_2 (dBm)	RSSI of T_1 (dBm)	RSSI of T_2 (dBm)
10	-45	-68	-	-	-49	-53	-48	-55	-	-
20	-47	-70	-	-	-47	-61	-49	-67	-	-
30	-47	-	-	-	-49	-68	-55	-67	-	-
40	-48	-	-	-	-50	-70	-52	-59	-	-
50	-47	-	-	-	-52	-68	-57	-65	-	-
60	-50	-	-	-	-55	-63	-57	-68	-	-
70	-48	-	-	-	-54	-65	-59	-62	-	-
80	-48	-	-	-	-62	-63	-64	-65	-	-
90	-53	-	-	-	-65	-68	-63	-60	-	-
100	-54	-	-	-	-64	-75	-65	-72	-	-
110	-55	-	-	-	-73	-73	-63	-72	-	-
120	-56	-	-	-	-65	-65	-63	-71	-	-
130	-60	-	-	-	-68	-62	-65	-77	-	-
140	-54	-	-	-	-64	-72	-65	-79	-	-
150	-54	-	-	-	-64	-66	-70	-79	-	-
160	-57	-	-	-	-69	-70	-70	-68	-	-
170	-59	-	-	-	-68	-67	-81	-68	-	-
180	-60	-	-	-	-75	-75	-81	-71	-	-
190	-67	-	-	-	-72	-75	-80	-73	-	-
200	-69	-	-	-	-73	-79	-80	-70	-	-

Table 5.1 The RSSI of the tags in θ=0°

Material	Iron		Copper		Plastic		Wood		Aluminium	
d (cm)	RSSI of T_1 (dBm)	RSSI of T_2 (dBm)	RSSI of T_1 (dBm)	RSSI of T_2 (dBm)	RSSI of T_1 (dBm)	RSSI of T_2 (dBm)	RSSI of T_1 (dBm)	RSSI of T_2 (dBm)	RSSI of T_1 (dBm)	RSSI of T_2 (dBm)
10	-49	-48	-	-	-48	-47	-48	-47	-	-
20	-47	-51	-	-	-47	-47	-48	-48	-	-
30	-48	-54	-	-	-49	-47	-50	-48	-	-
40	-47	-52	-	-	-52	-47	-50	-47	-	-
50	-48	-57	-	-	-52	-47	-55	-49	-	-
60	-49	-62	-	-	-57	-48	-56	-48	-	-
70	-49	-65	-	-	-58	-48	-60	-53	-	-
80	-49	-66	-	-	-59	-49	-60	-50	-	-
90	-50	-64	-	-	-59	-51	-61	-50	-	-
100	-56	-65	-	-	-63	-55	-63	-50	-	-
110	-64	-74	-	-	-64	-56	-64	-52	-	-
120	-64	-	-	-	-63	-58	-67	-56	-	-
130	-63	-	-	-	-65	-56	-71	-60	-	-
140	-52	-	-	-	-64	-56	-63	-60	-	-
150	-55	-	-	-	-64	-55	-62	-57	-	-
160	-54	-	-	-	-68	-59	-65	-58	-	-
170	-56	-	-	-	-69	-59	-69	-52	-	-
180	-58	-	-	-	-73	-61	-68	-60	-	-
190	-60	-	-	-	-73	-57	-73	-53	-	-
200	-65	-	-	-	-79	-61	-74	-55	-	-

Table 5.2 The RSSI of the tags in θ=90°

In this experiment, the distance (d) will be changed between 10 cm and 200 cm with a range of 10 cm with different materials in $\theta = 0°$ and $\theta = 90°$. As the goal of this experiment is to find out which materials of the cane will have a better performance, the graphs, which shown the relationship between the RSSI of different tags and the distance, are plotted with the data of Table 5.1 and Table 5.2 in the following:

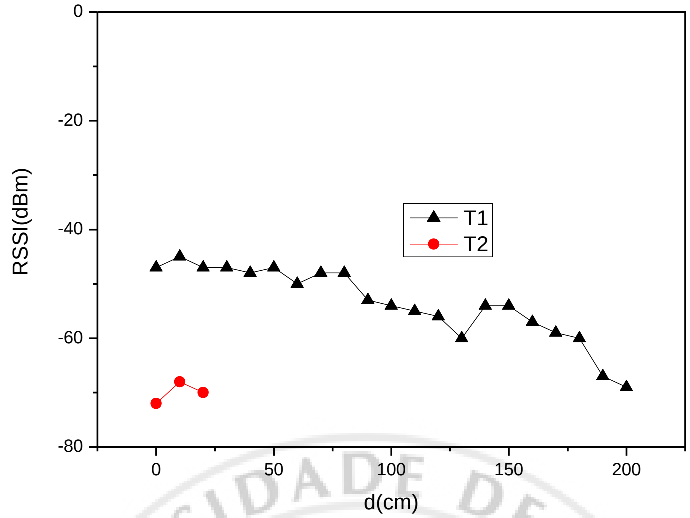


Fig. 5.4 RSSI of the tags with Iron cane in θ=0°

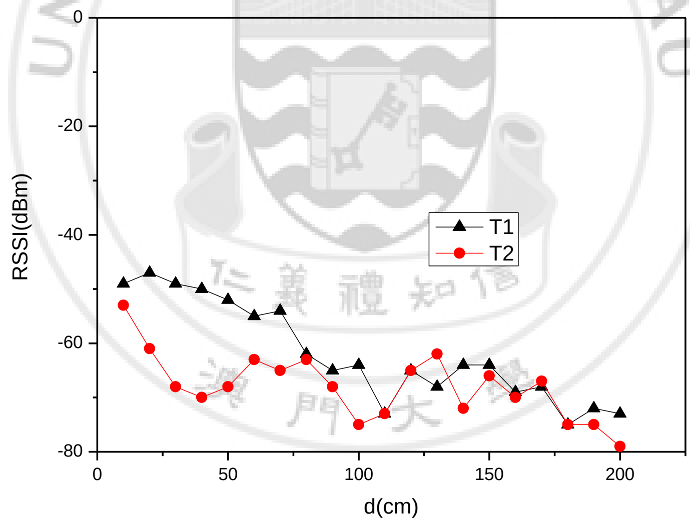


Fig. 5.5 RSSI of the tags with Plastic cane in θ=0°

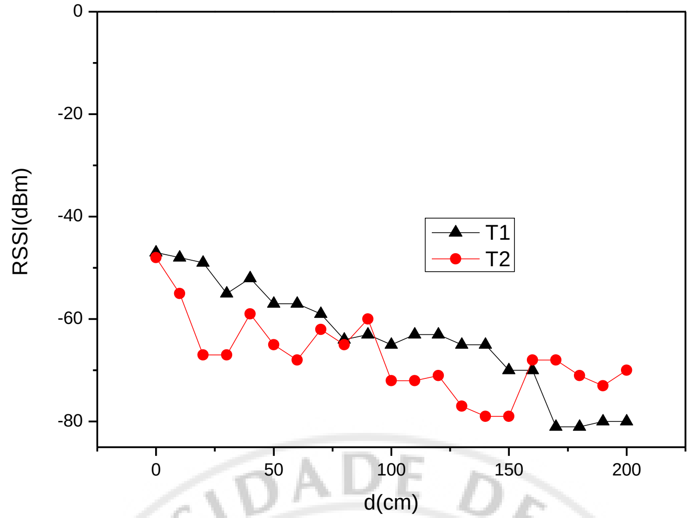


Fig. 5.6 RSSI of the tags with Wood cane in θ=0°

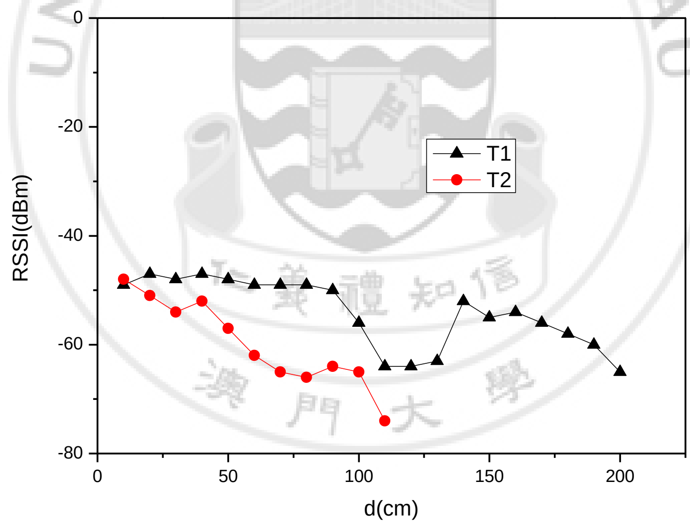


Fig. 5.7 RSSI of the tags with Iron cane in θ=90°

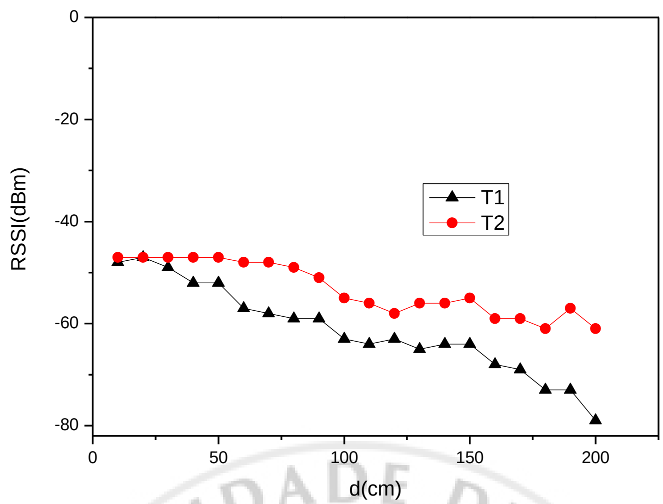


Fig. 5.8 RSSI of the tags with Plastic cane in θ=90°

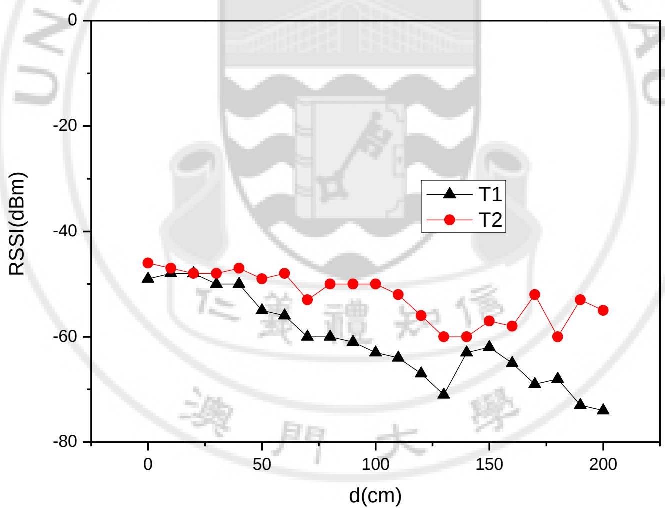


Fig. 5.9 RSSI of the tags with Wood cane in θ=90°

We can observe that the RSSI of the T1 and T2 are decreasing depend on the distance from Fig. 5.4 to Fig. 5.9. As the distance is increasing, the RSSI will decrease. Besides the distance (d), it shows that the RSSI will be affected by the angle from the comparison of the Fig. 5.4 to Fig. 5.6 with Fig. 5.7 to Fig. 5.9. The larger the angle, the smaller the RSSI. Moreover, as mentioned in section 2.7.2.3, the system do not perform well which the tag is attached on different materials. From Table 5.1 and Table 5.2, we can see that the RSSI with copper and aluminium is zero at all, which means that they affect the tags the most.

5.2.2 RSSI for RFID tag in different obstacles

In this experiment, the distance (d) of the RFID cane will be fixed at 100 cm in θ = 90°. This time, one obstacle with different materials shown as Fig. 10 will be placed between 10 cm and 100 cm in θ = 90° each time. As this experiment aims to find out whether the obstacle will affect the detection of RSSI or not, the data of the detection of RSSI and the graphs, which shown the relationship between the RSSI of different tags and the distance, are plotted in the following:

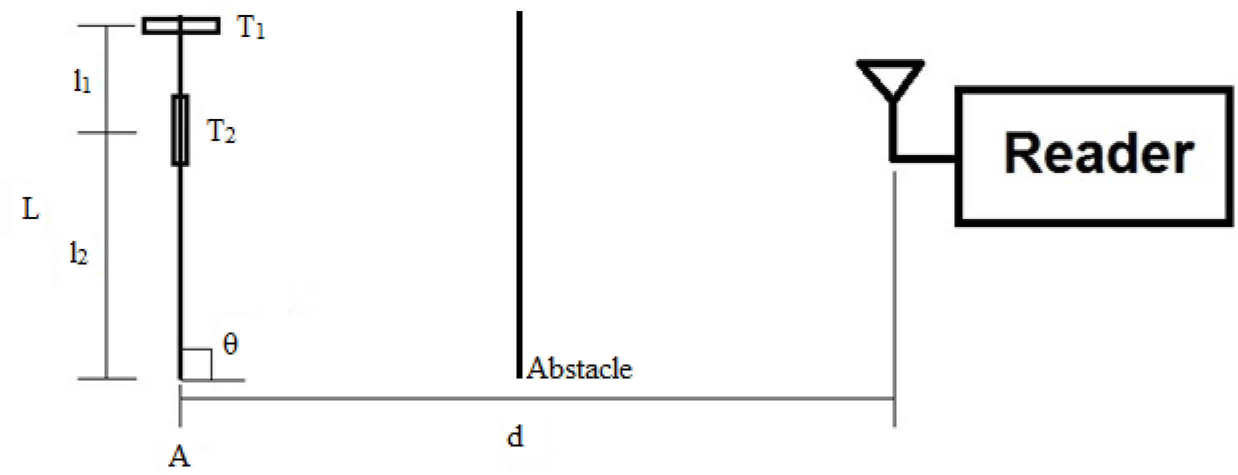


Fig. 5.10 The setup of the experiment for detecting RSSI for RFID tag in different obstacles

Material	**Iron**		**Copper**		**Plastic**		**Wood**		**Aluminium**	
d (cm)	RSSI of T_1 (dBm)	RSSI of T_2 (dBm)	RSSI of T_1 (dBm)	RSSI of T_2 (dBm)	RSSI of T_1 (dBm)	RSSI of T_2 (dBm)	RSSI of T_1 (dBm)	RSSI of T_2 (dBm)	RSSI of T_1 (dBm)	RSSI of T_2 (dBm)
10	-79	-	-	-	0	-64	-73	-64	-	-
20	-72	-	-	-	0	-78	-81	-63	-	-
30	-77	-	-	-	0	-64	-69	-57	-	-
40	-69	-	-	-	-75	-61	-65	-57	-	-
50	-77	-	-	-	-74	-67	-69	-64	-	-
60	-77	-	-	-	-76	-71	-76	-68	-	-
70	-77	-	-	-	-73	-68	-67	-69	-	-
80	-73	-	-	-	-70	-75	-80	-70	-	-
90	-71	-	-	-	-	-68	-75	-68	-	-
100	-	-	-	-	-	-	-	-	-	-

Table 5.3 The RSSI of the tags with copper board between the cane and reader

Material	Iron		Copper		Plastic		Wood		Aluminium	
d (cm)	RSSI of T_1 (dBm)	RSSI of T_2 (dBm)	RSSI of T_1 (dBm)	RSSI of T_2 (dBm)	RSSI of T_1 (dBm)	RSSI of T_2 (dBm)	RSSI of T_1 (dBm)	RSSI of T_2 (dBm)	RSSI of T_1 (dBm)	RSSI of T_2 (dBm)
10	-49	-70	-	-	-73	-54	-	-51	-	-
20	-49	-73	-	-	-73	-55	-	-50	-	-
30	-52	-72	-	-	-72	-55	-	-50	-	-
40	-56	-72	-	-	-72	-56	-	-50	-	-
50	-48	-73	-	-	-71	-57	-	-50	-	-
60	-52	-73	-	-	-72	-57	-	-53	-	-
70	-52	-70	-	-	-72	-56	-	-53	-	-
80	-51	-70	-	-	-72	-56	-	-53	-	-
90	-54	-68	-	-	-72	-55	-	-54	-	-
100	-48	-67	-	-	-	-55	-	-49	-	-

Table 5.4 The RSSI of the tags with plastic board between the cane and reader

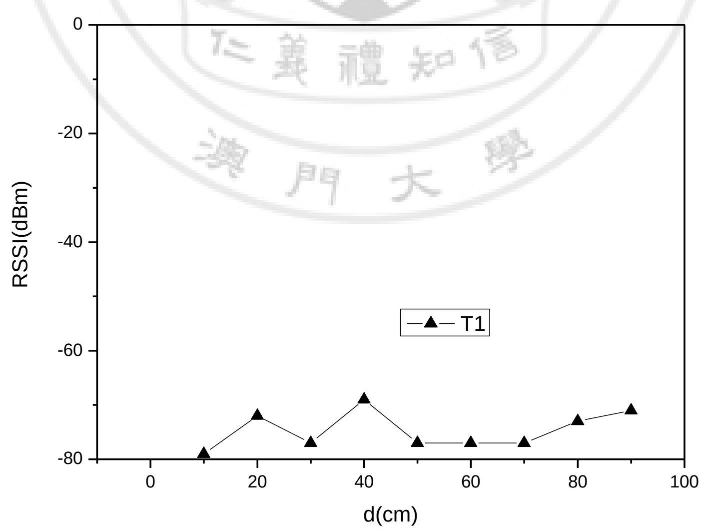


Fig. 5.11 RSSI of the tags of iron cane with copper board between the cane and reader

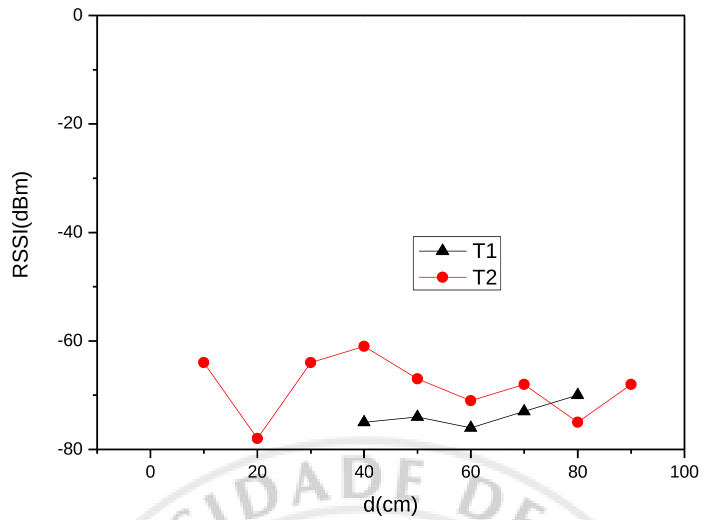


Fig. 5.12 RSSI of the tags of plastic cane with copper board between the cane and reader

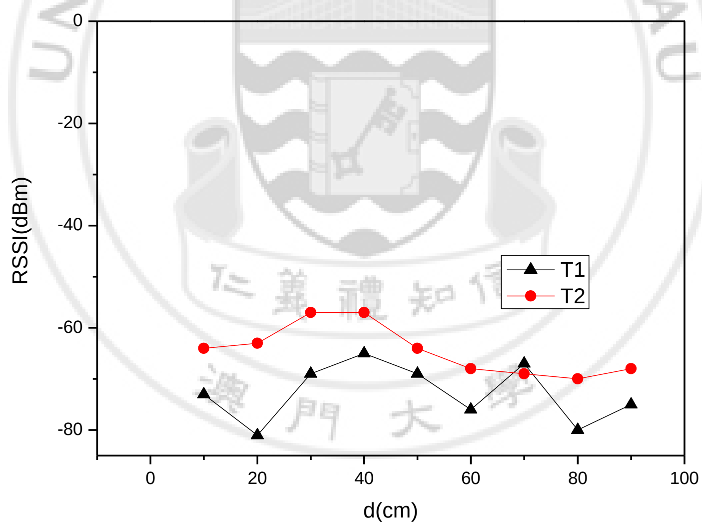


Fig. 5.13 RSSI of the tags of wood cane with copper board between the cane and reader

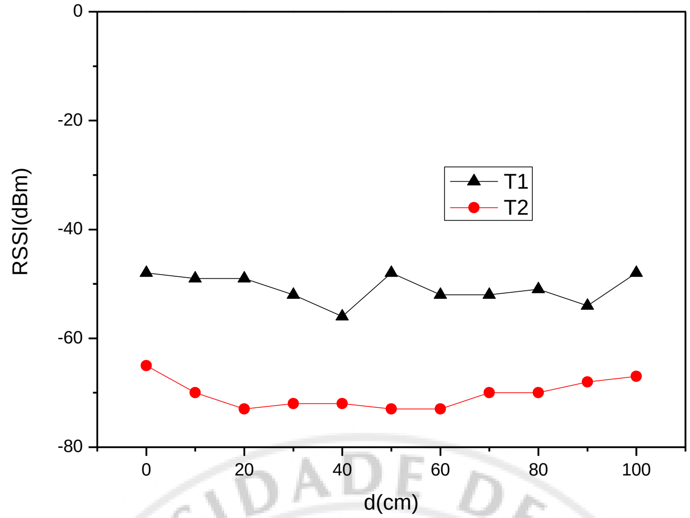


Fig. 5.14 RSSI of the tags of iron cane with plastic board between the cane and reader

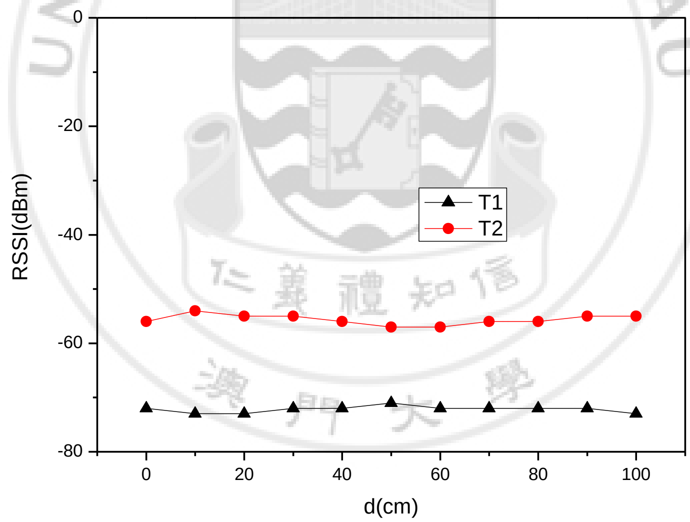


Fig. 5.15 RSSI of the tags of plastic cane with plastic board between the cane and reader

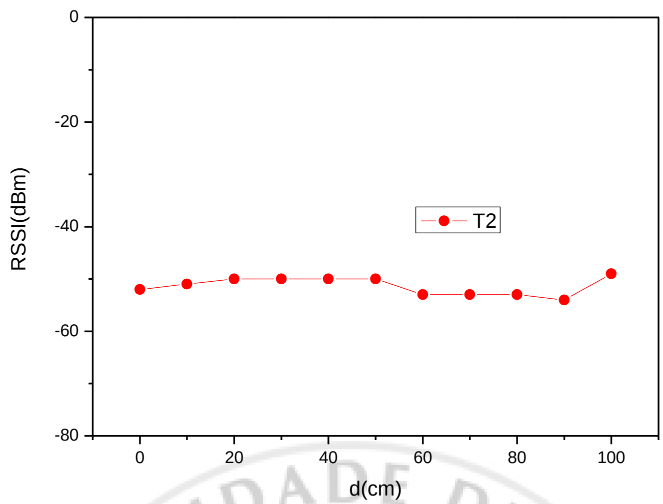


Fig. 5.16 RSSI of the tags of wood cane with plastic board between the cane and reader

From the comparison of the Fig. 5.11 to Fig. 5.13 with Fig. 5.14 to Fig. 5.16, it is obvious that the tags perform well in free space rather than the copper and the plastic board. From section 2.7.2.3, it is known that detuning occurs if the materials are in close proximity to the tag and the read ranges will be reduced up to three times in proximity of metal in comparison with the range in free space. We can see that the RSSI in d = 0 is undefined, which means that the detuning appear.

5.2.3 System testing

From the operation mentioned in section 4.3, the figures of the test are shown as following:

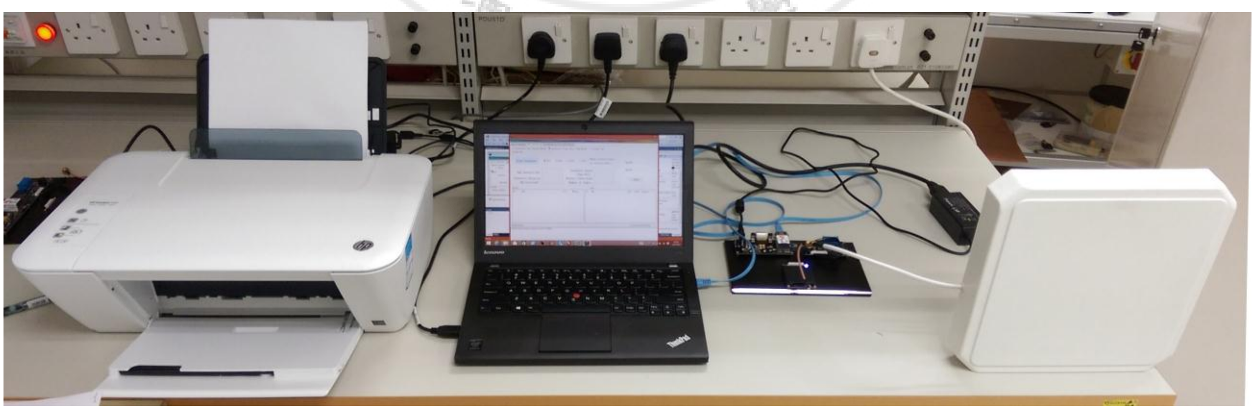


Fig. 5.17 The Setup of the whole system

From Fig. 5.17, it shows the connection between the reader and the host computer, as well as the connection between the printer and the host computer clearly. First of all, we have to hold the

RFID cane with a specified angle to the reader like the one illustrated in Fig. 5.18. Then, the program will run the code [Appendix D] to do the analysis and it will perform the Voice to text function. After analyzing from the host computer via the program, the specified service such as printing the stamp or printing the post card will be done as shown in Fig. 5.19.

Fig. 5.18 The posture of the cane

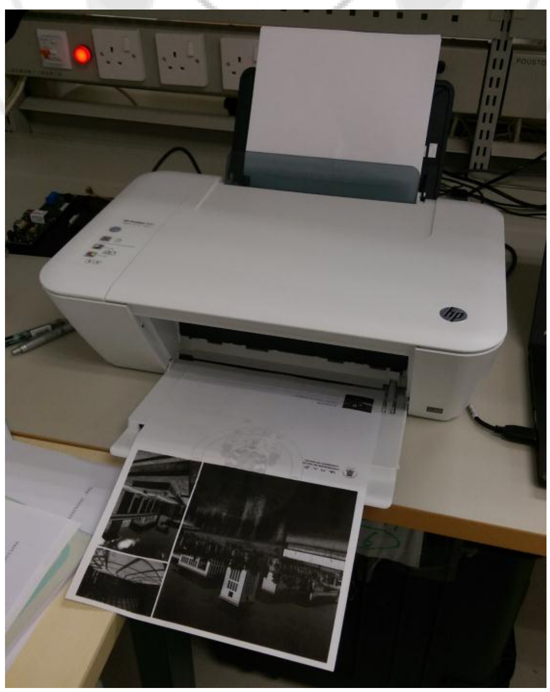


Fig. 5.19 Printing the post card

5.3 Conclusion

In this project, using two tags to detect the position of the cane is the goal of the application so we have to choose a suitable distance (d) that the reader can detect the RSSI of the tags clearly. As a result, the best distance (d) of this project is 100 cm for the VIP to use the cane. From Chapter 2, it is said that the relative orientations of the tag and the reader will affect the performance of the system. In other words, the system can have a better performance if the angle of the tags is 90°. Although the cane of wood and the cane of plastic have a better performance than the iron, we have to concern that the strength and the mobility of the cane are the requirement of the cane to VIP.

CHAPTER 6 SUMMARY

Radio Frequency Identification (RFID) is a wireless use of radio waves to exchange the data between reader and tag attached to an object. The operation of the RFID can be classified in term of the requirement of frequency of the application such as low frequency (LF), high frequency (HF), ultra high frequency (UHF) and microwave frequency (MW). According to the properties of different types of frequency, we can conclude that the UHF tag would be the best choice in this project.

Nowadays, there are many assistive products for VIP such as the I-Cane and the Thimble, but the products for solving the problems of the postal services are still insufficient. By applying the principle of polarization, which is one of the fundamental characteristics of any antenna, the Received Signal Strength Indicator (RSSI) detected by the reader will be varied in different conditions. In all conditions, the controlling via the posture of the cane can be done. The kiosk for applying the postal services controlled by the RFID cane is the target in this project.

From Chapter 2, it has reviewed a typical RFID system, which includes tag, reader and the antenna. Tags are classified into passive, semi-passive and active in order to fulfill different reading range and requirement. RFID Reader and antenna act as a communicated device to connect the tags and host computer.

On the other hand, the standards and regulations of RFID, namely “The international organization for standardization” (ISO) and “The EPC global”, were summarized in the section 2.6. Generally, the differences between them are the operating frequency, coding scheme and air interface.

Moreover, the conditions, which will affect the performance of the RFID tag such as the tag orientation; deployment environment and the material of the object on which the tag is placed are explained.

As we mentioned before, the polarization is the principle of the RFID cane in this project; and the definitions and properties of different types of polarization such as linear polarization, circular polarization and elliptical polarization are explained in Chapter 3.

The idea of the RFID enabled control mechanism is displayed in Chapter 4. In this chapter, the elements of this project like the cane, the tags, the RFID reader and the host computer is being explained in detail. To the cane, the model should follow the ISO 23599:2012 which is the standard of producing products for VIP. Also, the operation of the whole system of this project such as holding the cane, voice to text function and printing is performed.

The experiments which are discussed in Chapter 5 aim to find out the best condition to have a most effective performance of RFID detection. There are three parts of it, which are the system setup, the testing result and the conclusion. From the testing results, we can observe that the best performance can be achieved with the iron RFID cane and the obstacle is air which means the free space.

Although the RFID is employed conveniently to replace barcodes in contactless data capturing, the drawback of it is the cost of the RFID tags are high and low robustness. For the future work, as this project has to achieve the lowest cost of products for VIP, we can focus on the development of chipless RFID tags. Even it can reduce the cost of the cane, the size of the tag will be increase. Therefore, the goal of reducing the cost should be focus on the material and the chipless tag respectively.

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APPENDIX

APPENDIX A

ISO Standard and Safety Concern for VIP

✔ ISO 23599:2012
Assistive products for blind and vision-impaired persons -- Tactile walking surface indicators

✔ ISO 23600:2007
Assistive products for persons with vision impairments and persons with vision and hearing impairments -- Acoustic and tactile signals for pedestrian traffic lights

✔ ISO 24415-1:2009
Tips for assistive products for walking -- Requirements and test methods -- Part 1: Friction of tips

✔ ISO 24415-2:2011
Tips for assistive products for walking -- Requirements and test methods -- Part 2: Durability of tips for crutches

A.1 Introduction

As there are several ISO for the assistive products for VIP, the ISO which is suitable to this project is ISO 23599:2012. The purpose of it is to create requirements for tactile walking surface indicators (TWSIs) for blind or vision-impaired persons. When blind or vision-impaired persons travel alone they might encounter problems and hazards in various situations. In order to obtain information for way finding, these pedestrians use information available from the natural and built environment, including tactual, acoustic and visual information. However, environmental information is not always reliable; it is for this reason that TWSIs perceived through use of a long white cane, through the soles of the shoes and through use of residual vision have been developed. TWSIs should be designed and installed based on a simple, logical and consistent layout. This will enable tactile indicators to facilitate not only the independent travel of blind or vision-impaired persons in places they frequently travel, but also to support their independent travel in places they visit for the first time.

Currently, there are several forms of TWSIs, but the ability to detect differences in tactile patterns through the soles of the shoes or the long white cane varies depending on individual differences. Therefore, the consolidated findings of science, technology and experience were employed to define the characteristics of TWSIs that can be detected and recognized by potential users. Additionally, in order to ensure that TWSIs achieve maximum effect in conveying information, it is important that they be installed in or on a smooth surface where blind or vision-impaired persons can identify them without interference from an irregular walking surface.

It is also necessary to ensure that TWSIs can be effectively used by vision-impaired persons as well as people who are blind. For this purpose, TWSIs should be easily detectable through use of residual vision. This is achieved through visual contrast between TWSIs and the surrounding or adjacent surface. Visual contrast is influenced primarily by luminance contrast, and secondarily by difference in colour or tone. In order to have good visibility, it is necessary to have sufficient illumination without glare and it is important to maintain the visual contrast between TWSIs and the surrounding or adjacent surface.

While TWSIs should be effective for blind or vision-impaired persons, attention should also be paid to their surface structure and materials in order to ensure that all pedestrians, including those with impaired mobility, can safely and effectively negotiate them.

TWSIs are installed in public facilities, buildings used by many people, railway stations and on sidewalks and other walking surfaces. Attention patterns may be installed in the vicinity of pedestrian crossings, at-grade kerns, railway platforms, stairs, ramps, escalators, travelators, elevators, etc. Guiding patterns may be used alone or in combination with attention patterns in order to indicate the walking route from one place to another.

A.2 Scope of ISO 23599:2012

This International Standard provides product specifications for tactile walking surface indicators (TWSIs) and recommendations for their installation in order to assist in the safe and independent mobility of blind or vision-impaired persons.

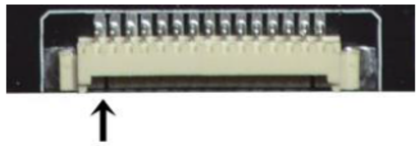
This International Standard specifies two types of TWSIs: attention patterns and guiding patterns. Both types can be used indoors and outdoors throughout the built environment where there are insufficient cues for way finding, or at specific hazards.

Some countries have adopted other designs of TWSIs based on the consolidated findings of science, technology and experience, ensuring that they can be detected and distinguished by most users. National standards, regulations and guidelines governed by national legislation specify where TWSIs are to be used. This International Standard is not intended to replace requirements and recommendations contained in such national standards, regulations or guideline

APPENDIX B

UHF RFID Reader Data Sheet

Module Type	M-2600	M-2800
Real Photo		
RF Channel	Single Channel	Four channel
RF Connector	MMCX	SMA
Antenna Connection Mode	Can be configured as a single antenna or bistatic mode	Bistatic is unavailable
Interface Connector	Molex 53261-1571	
RF Connectors Material	Gold-plated brass	
PCB Material	Rogers FR4 gold-plated	
Shield Material	Aluminum	



PIN 1

PIN	Interface	Description
1	GND	Meanwhile grounding
2	GND	
3	3.7V – 5V DC	Meanwhile connect power
4	3.7V – 5V DC	
5	GPIO 3	Output
6	GPIO 4	Output
7	GPIO 1	Input
8	Beeper	Has driven with > 50mA output current
9	UART_RXD	TTL level
10	UART_TXD	
11	USB_DM	For testing
12	USB_DP	
13	GPIO 2	Input
14	EN	High level enable
15	GPIO 5	RS-485 direction control

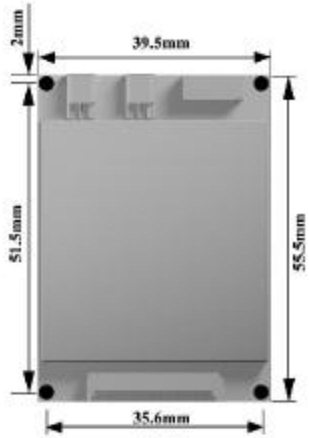
	Feature	Description
1	Based on Indy R2000 chip	◆ RF transceiver is Impinj Indy R2000.
2	High performance anti-collision algorithm	◆ The best algorithm in this industry. ◆ It provides the highest efficiency.
3	Optimized algorithm for a little of tags	◆ Better tag response time. ◆ Optimized for small tag quantity applications.
4	Dual CPU architecture	◆ Main CPU is responsible for tag inventory, assistant CPU is responsible for data management. ◆ Inventory and data transfer are parallel and simultaneous. This feature improves the total performance significantly. ◆ Assistant CPU is responsible for generating real random number. ◆ Assistant CPU is responsible for system operating surveillance.
5	Fast 4 antenna switch inventory	◆ High speed inventory therefore antennas could be switched rapidly. The minimum inventory duration for an antenna is 25ms. ◆ Every antenna's inventory duration is configurable.
6	Two inventory modes	◆ Buffer mode and real time mode. ◆ In buffer mode, inventoried tag will be stored in buffer. This mode improves the efficiency of multi tag inventory. ◆
7	Hardware system halt detection	◆ Hardware CPU status surveillance. ◆ Run for 24hours X 365 days without system halt.
8	Low operation voltage	◆ The lowest operating supply voltage is 3.7V. ◆ Can be powered by lithium battery.
9	Low power consumption	◆ Maximum out power only needs 1.3A +/-10%. Current.
10	PA health surveillance	◆ PA status surveillance. ◆ Make sure PA never works under saturated state. Protected it for long term operation.

11	18000-6B/C full compatible	◆ 100% 18000-6B/C compatible. ◆ Can be switched rapidly between protocols.
12	18000-6B large data read/write	◆ Read 216 bytes in one time takes less than 500ms. ◆ Write 216 bytes in one time takes less than 3.5s. ◆ Can also read/write data with various lengths. ◆ Extremely stable (approximate 100% success rate).
13	Antenna connection detection	◆ Detect antenna connection. ◆ Protecting RF receiver. ◆ Can be cancelled by command.
14	Bistatic antenna configuration	◆ Bistatic antenna configuration improves receive sensitivity by 13dB.
15	High power LED driver	◆ Can output 50mA output current to drive a high power LED.
16	Excellent onboard power system	◆ 8 independent power supplied on board. Every unit is supplied independently. ◆ Each power supply has soft start function. Improves the stability of the power supply system.
17	Multi-board temperature sensor	◆ Multi point surveillance, Accurate monitoring system operating temperature.
18	Dual backup power output correction	◆ Make sure output power can be fine adjusted. ◆ Two mutually backup power parity modules. Unless also damaged, the system can operate normally.
19	Concise and effective command system	◆ Serial communication interface. ◆ Simple, convenient and effective for easy integration.
20	Excellent thermal design	◆ All heating devices have thermal structure. ◆ A large area of heat sink contact surface. ◆ Thermal coupling interface using high thermal conductivity solid materials which are non-volatile under high temperature.

Electrical Characteristics

Operating Voltage	3.7V – 5 V
Standby Mode Current	<50mA (EN high level)
Sleep Mode Current	<100uA (EN low level)
Operating Current	1.2A +/-10%
Operating Temperature	- 20 ℃ - + 55 ℃
Storage Temperature	- 20 ℃ - + 85 ℃
Humidity	< 95% (+ 25 ℃)
Air Interface Protocol	EPC global UHF Class 1 Gen 2 / ISO 18000-6C ISO 18000-6B
Spectrum Range	860Mhz – 960Mhz
Supported Regions	US, Canada and other regions following U.S. FCC Europe and other regions following ETSI EN 302 208 with & without LBT regulations Mainland China Japan Korea Malaysia Taiwan
Output Power	20 – 33dBm
Output Power Precision	+/- 1dB
Output Power Flatness	+/- 0.2dB
Receive Sensitivity	< -85 dBm
Peak Inventory Speed	> 700 tags/sec
Tag Buffer Size	1000 tags @ 96 bit EPC
Tag RSSI	Supported
Antenna Detector	Supported
Ambient Temp Monitor	Supported
Working Mode	Single/DRM
Host Communication	TTL Uart port
GPIO	2 inputs optical coupling 2 outputs optical coupling
Max Baud Rate	115200 bps
Heat Dissipation	External cooling fin

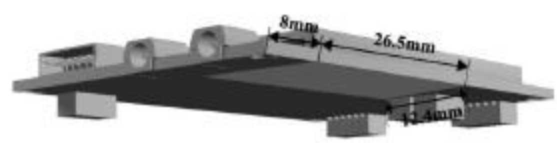
Contour and hole location



Mounting hole diameter and shield location

Highest point and lowest point

Radiator mounting location



APPENDIX C

UHF RFID Passive Tag Data Sheet

UPM Rafsec RFID Products for Retail Supply Chain Management

Protocol	**EPC Class 1 Gen 1** Rafsec OneTennaTM	**EPC Class 1 Gen 1** Rafsec OneTennaTM	**EPC Class 1 Gen 2** Rafsec OneTennaTM	**EPC Class 1 Gen 2** Rafsec OneTennaTM
Frequencies available	868 MHz 902–928 MHz 950 MHz	868 MHz 902–928 MHz 950 MHz	868 MHz 902–928 MHz 950 MHz	868 MHz 902–928 MHz 950 MHz
Antenna size	93 x 11 mm 3.661 x 0.433″	64 x 66 mm 2.520 x 2.598″	93 x 11 mm 3.661 x 0.433″	64 x 66 mm 2.520 x 2.598″
Die-cut size	97 x 15 mm 3.819 x 0.590″	76.2 x 76.2 mm 3 x 3″	97 x 15 mm 3.819 x 0.590″	76.2 x 76.2 mm 3 x 3″
Delivery format				
Wet inlay	●	●	●	●
Dry inlay	●	●	●	●
Tag	●	●	●	●
Application				
	• corrugated cases, plastic trays and components • high-speed applications • compatible with 4″ wide printers and labels • strong performance	• corrugated cases, plastic trays and components • compatible with 3 x 3″ printers • excellent performance and high read range	• corrugated cases, plastic trays and components • high-speed applications • compatible with 4″ wide printers and labels • can be applied directly onto corrugated cases • strong performance • case-level product	• corrugated cases, plastic trays and components • compatible with 3 x 3″ printers • excellent performance and high read range • case-level product

APPENDIX D

RFID Reader Interfacing Program Source Codes

As the number of lines of code is too much to this paper, the main part of the code for controlling the voice to text function and the printing is shown as following:

D.1 The library

```
using System;
using System.Collections.Generic;
using System.ComponentModel;
using System.Data;
using System.Drawing;
using System.Linq;
using System.Text;
using System.Windows.Forms;
using System.Net;
using System.Drawing.Printing;
using System.IO; //Printing
using System.Collections; //Printing
using System.Speech.Synthesis; //Voice to text
```

D.2 The variable for the voice to text function

```
string[] FYPEPC = { "00", "01" };
string c = "" ;
int[] FYPRSSI = { 0, 0 };
int[] FYPcount = { 0, 0 };
byte a = 0;
bool FYPPRINT = true;
string speech = "You are now in E ,eleven, FST Building in Hang Qi Campus";
SpeechSynthesizer reader1;
```

D.3 The printing function

```
private PrintDocument printDoc = new PrintDocument();
private PageSettings pgSettings = new PageSettings();
private PrinterSettings prtSettings = new PrinterSettings();
```

D.4 The printing function

```
void printDoc_PrintPage(Object sender, PrintPageEventArgs e)
{
string RSSI = "";
if (FYPPRINT == true)
{RSSI = "Vertical_Test_Final";}
else if (FYPPRINT == false)
{RSSI = "Horizontal_Test_Final";}

String textToPrint = RSSI;
Font printFont = new Font("Courier New", 12);
int leftMargin = e.MarginBounds.Left;
int topMargin = e.MarginBounds.Top;
e.Graphics.DrawString(textToPrint, printFont, Brushes.Black, leftMargin, topMargin);
```

```
System.Drawing.Image img = System.Drawing.Image.FromFile(System.IO.Directory.GetCurrentDirectory() +
"\\umac_postcard.jpg"); //poster
//System.Drawing.Image img = System.Drawing.Image.FromFile(System.IO.Directory.GetCurrentDirectory() +
"\\umac_stamp.jpg"); //stamp
Point loc = new Point(10, 10);
//  e.Graphics.DrawImage(img, loc);
        }
```

D.5 The voice to text function

```
void Form1_Load(object sender, EventArgs e)
{
  reader1 = new SpeechSynthesizer();
}
void openFileDialog1_FileOk(object sender, CancelEventArgs e)
{
   speech = File.ReadAllText(openFileDialog1.FileName.ToString());
}
```

D.6 The printing function

```
FYPPRINT = true;
this.Menu = new MainMenu();
printDoc.PrintPage += new PrintPageEventHandler(printDoc_PrintPage); printDoc.PrinterSettings.PrinterName = "HP
Deskjet 1510 series";
printDoc.Print();
```

D.7 The printing function

```
FYPPRINT = false;
this.Menu = new MainMenu();
printDoc.PrintPage += new PrintPageEventHandler(printDoc_PrintPage);
printDoc.PrinterSettings.PrinterName = "HP Deskjet 1510 series";
printDoc.Print();
```