Low Frequency RFID Based Object Identification System for Blind People: RFASSIST

Megha Agarwal and Dr.S.R.N.Reddy

Abstract- Radio Frequency Identification (RFID) technology has applications from retail sector to health sector. This paper presents a low frequency RFID based Object Identification System (RFASSIST) that has been produced to help blind people to identify various objects. RFID appears as an effective solution to provide object identification. The paper also gives an overview of the RFID technology. RFASSIST uses an 8-bit PIC Microcontroller to interface RFID Reader Module. RFID reader tracks an object carrying passive RFID tag in an indoor environment. Microcontroller processes signals received from RFID reader. To provide assistance to the blind, the framework combines RFID based object identification with audio messages. It also displays the object's name on LCD. This project stores the date and time of identification of object on PC using RS232 serial communication. The data was successfully stored in computer's memory which can be later used as a database in certain applications. During the course of the project indoor experiments have been conducted. This system successfully identified various objects for application domains such as home care, library management, toll gate etc. for blind.

Keywords- Audio messages, Low frequency, Microcontroller, Object Identification, Radio Frequency Identification (RFID) technology, RS232 serial communication.

1. INTRODUCTION

Sense of Sight is one of the basic senses of a normal human being. It renders life quite difficult for a blind person. Visually impaired people have difficulty in navigating in unknown campuses. As well, they must have every detail about indoor environment. Large obstacles can cause them injuries, so they should be kept aside. They also have difficulty in locating various objects. For them object identification and physical movement is one of the biggest challenges [5], [8], [11], [16], [21]. Many people with serious visual impairments can identify objects and navigate independently, using a wide range of tools and techniques. For providing assistance to differently abled person several devices such as One click method-arm approach [2], Wireless sensor network [3], Automatic speech recognition [15], Finger Braille [23], RFID [1,4,8,9,10,11,12,13,16,18,20,21,22,24] have been proposed. Amongst these RFID appears to be an effective solution for the visually impaired people.

Radio Frequency Identification (RFID) is a method of storing and remotely retrieving data via a radio frequency transmission by using devices called RFID readers (receivers) and RFID tags (transponders). RFID system mainly operates in four ranges of frequency spectrum: low, high, ultrahigh and microwave. Low frequency RFID systems operate at 125 KHz and have a read range of less than 0.5m. High frequency systems operate at 13.56 MHz and provide a read range of approximately 1 m. Similarly, Ultrahigh and Microwave frequency systems operate at 860 MHz and 2.4 GHz and provide read range of 3m and 1m, respectively. RFID tags are inexpensive, bar-code sized stickers that contain an antenna and a microchip that can be sensed wirelessly by an RFID reader. Information on RFID tags usually contains at least a unique id. When RFID reader transmits a signal to the tag, tag communicates its identity to the reader. The information can be read and sometimes written at distances of up to 30 feet, depending on the system. Tags are of two types: Active and Passive. Active tags possess batteries that supply power for their communication circuitry [1]. They have long wireless range and can achieve high data rates. In contrast, passive tags don't have interior power supply and they rely on interrogator for power. Thus, they are not limited by battery life. There are numerous application specific and vendor specific tag types. Common formats include disk or coin tag, smart label, contact-less Smart Card. There are many other available formats like plastic housed, coil mounted tags etc. A detailed review of RFID Technology and its design and implementation is given by the authors et. al. [12], [24]. RFID has become widespread in retail and shipping where it is used as an alternative to bar codes to detect and identify products and shipments. In recent years, RFID based identification have become popular in applications such as security systems, library management, vehicle security, electronics barcode labels and toll systems [9].

This work implements a low frequency RFID based object identification system for the blind people (see Fig. 1). In indoor environment, blind people can identify several objects using RFID reader which identifies objects carrying passive RFID tags. This information is relayed to the microcontroller, which then plays a pre recorded message when the object is identified. This information can also be stored on PC using RS232 communication interface. Hence, this system can be used in several applications like library management. It also shows opening and closing of gates upon tag identification. Thus, this system can also be used in security and toll systems. Many experiments have been successfully conducted to demonstrate such applications. Results have also been compared with the existing systems and plotted. Installation is easy, development cost is low, and efficiency is good below 0.5m. The other advantage is that it is applicable in indoor environment. This paper is

organized as follows: Section 2 gives the review of various RFID applications; Section 3 describes the system hardware and software architecture and its functionalities; Section 4 describes various experiments conducted and derives results. Finally Section 5 concludes the paper and proposes future work.

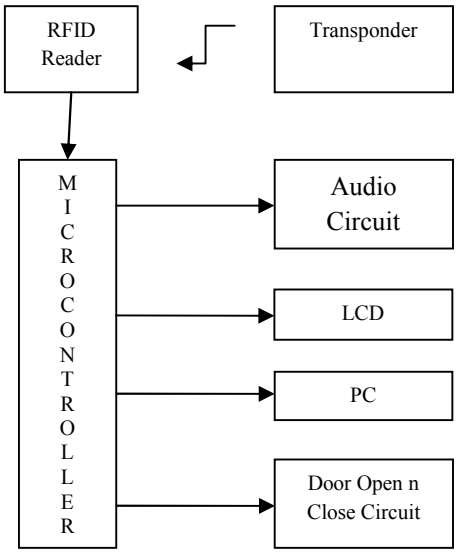


Fig. 1: RFASSIST Overview. The system utilizes RFID to detect objects in an indoor environment for blind people.

2. RELATED WORK

For related researches on RFID [1], [4], [5], [8], [9], [10], [11], [16], [18] and [22] are the prominent examples. RFID systems have become common for identifying and tracking objects as discussed before. Such systems have been proposed in [4], [5], [8], [11], [16]. Elif et al. [4] proposed RFID based Moving object tracking system. This paper presents a study on localization and tracking of an object carrying an active RFID tag. The Study incorporates processing of the signals received from transmitters, in a way to locate and track the coordinate in an indoor environment. Here, Bayes Decision Rule and Kalman Filter approach were introduced separately to improve the performance of location estimation and tracking in presence of obstacles. They provided a read range of 2m and 5m respectively. However, Received Signal Strength (RSS) was influenced by scattering and reflection of radio waves. It resulted in low accuracy. Ersin et al. [5] developed An RFID application: Path Finder, which was very accurate to allow the user group to reach the target within a non familiar or totally unknown campus area without taking any help from outside. But the Path Finder could not achieve expected results in case of more than one target. Also tags were not read if they were far away than 35cm. Read range was improved drastically in the system developed by Mohsin [11]. He developed An RFID Based Navigation and Object Recognition Assistant for Visually Impaired People. This system was proposed for the assistance of blind people. The system incorporated a mobile RFID reader module with object management system with three main functionalities: to access and manage targeted an integrated Zigbee transceiver for transmitting the tag's information. Utensils and other objects in the house or building carry the tags and transmit the data wirelessly to the server embedded. An audio file, recorded for and unique to each object, resides on the server. The reader reads PC which in turn scans for the particular ID in the database and plays the corresponding audio file. This system provides excellent voice quality within 100m. But it requires refinement and use of accurate reader modules to handle interference problems. The system is expensive because of use of Zigbee transceivers. Cost was greatly reduced in the system developed by Sakmongkon et al. [16]. He developed Blind Navigation System for Indoor Environments using UHF RFID systems. This system uses a passive communication circuitry and is capable of locating tags up to 10-15 m. The cost in this system was reduced as the connection to the server was only when navigation starts. In this paper rechargeable batteries were used which greatly removed the problem of limited battery life. But some communication delay was observed. The transponder cost was greatly reduced by reusing obsolete transponders available from livestock identification by Lorenzo Faggion [8] which are also fully operable in different adverse environments. The paper proposed by him presented low frequency RFID based Mobility Network for Blind People. The use of Smart phones resulted in compatibility and portability problems associated with it. A visual aid system (VAS) for blind was also developed based on RFID and fast symbol recognition which achieved good performance in embedded devices. VAS perceives all blind symbols in current scene and reports location information to blind by text-to-speech technology. This helps to achieve real time effects.

Other RFID applications also exist which result in low cost and improved battery life. Alanson et al. [1] presented the Wireless Identification and Sensing Platform (WISP). WISP is a programmable battery free sensing and computational platform designed to explore sensor-enhanced radio frequency identification (RFID) applications. It exclusively operates from harvested RF energy and uses a 16-bit ultralow-power microcontroller to perform sensing and computation. The microcontroller encodes compliant ID and dynamically computes the required 16-bit cyclical redundancy checking (CRC). But in this, Power consumption is high and there is loss in signal strength over transmission. Martin et al. [9] developed low cost wireless sensor system and presented its application in dental retainers. Use of wireless links reduced high risk of inflammatory disease but battery capacity and power consumption limited its performance.Other applications include object management system and mobile telecommunication services. Meenakshi et al. [10] focused on the applications of RFID technology in mobile telecommunication services. Here, mobile phone can be both tag and reader at the same time but economic and standardization issues need to be handled. Taketoshi et al. [18] developed indoor

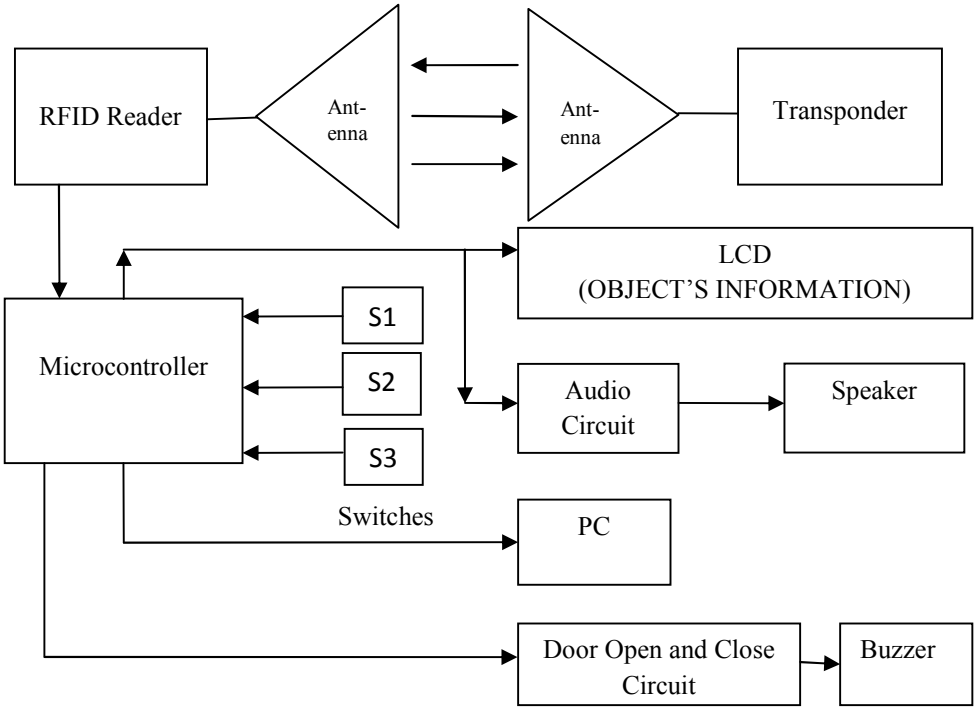


Fig. 2: Block Diagram of RFASSIST

objects, real time monitor locations and search particular information from database. In this, floor embedded pressure sensors reduces interference from obstacles and computation time but it makes use of complex algorithms.

From the above discussion it is concluded that RFID is a powerful tool for providing assistance to the blind. There is a possibility of designing a cost effective system which has an improved performance in most of the respects and will also work optimally in many different applications. RFID based systems appeared to be the best promising solution and easy to use.

In the nutshell, RFID is only one of numerous technologies grouped under the term Automatic Identification (Auto ID), such as bar code, magnetic inks, optical character recognition, voice recognition, touch memory, smart cards, biometrics etc. Auto ID technologies are a new way of controlling information and material flow, especially suitable for large production networks. The RFID technology is means of gathering data about a certain item without the need of touching or seeing the data carrier, through the use of inductive coupling or electromagnetic waves. The data carrier is a microchip attached to an antenna (together called transponder or tag), the latter enabling the chip to transmit information to a reader (or transceiver) within a given range, which can forward the information to a host computer. The middleware (software for reading and writing tags) and the tag can be enhanced by data encryption for security-critical application at an extra cost. RFID is the technology of choice for object identification and tracking.

3. RFASSIST ARCHITECTURE AND FUNCTIONALITIES

We designed a low cost RFID based solution for blind people or visually impaired to recognize objects in a room. A block diagram of the system is shown in Fig. 2. This system consists of a RFID reader interfaced with microcontroller. The passive tags are placed on various objects such as laptop, books, DVD's and other objects in the house or building. RFID reader fetches tag's information and sends it to the microcontroller. This information can be used accordingly for different applications. For this purpose, three switches have been provided. When switch 1 is pressed, Microcontroller will play the corresponding audio file recorded for and unique to each object, residing in the audio circuit's memory. The audio playback is relayed to microcontroller. Additionally, the corresponding object's name is also displayed on the LCD. When switch 2 is pressed, tag's information is serially transferred to the PC using serial RS232 communication interface. This would create a database in PC's memory. It also records date and time of identification in the database. This database can be used later in library management system. When switch 3 is pressed, a gate connected to the microcontroller would open and a buzzer will also play when the correct tag is identified. After some time the gate will close automatically and again the buzzer will be heard. When some invalid card is detected, gates will remain close. This feature can be used in toll gates where RFID tags enabled car would not require any tickets.
This will save lot of time and will ease traffic conditions.

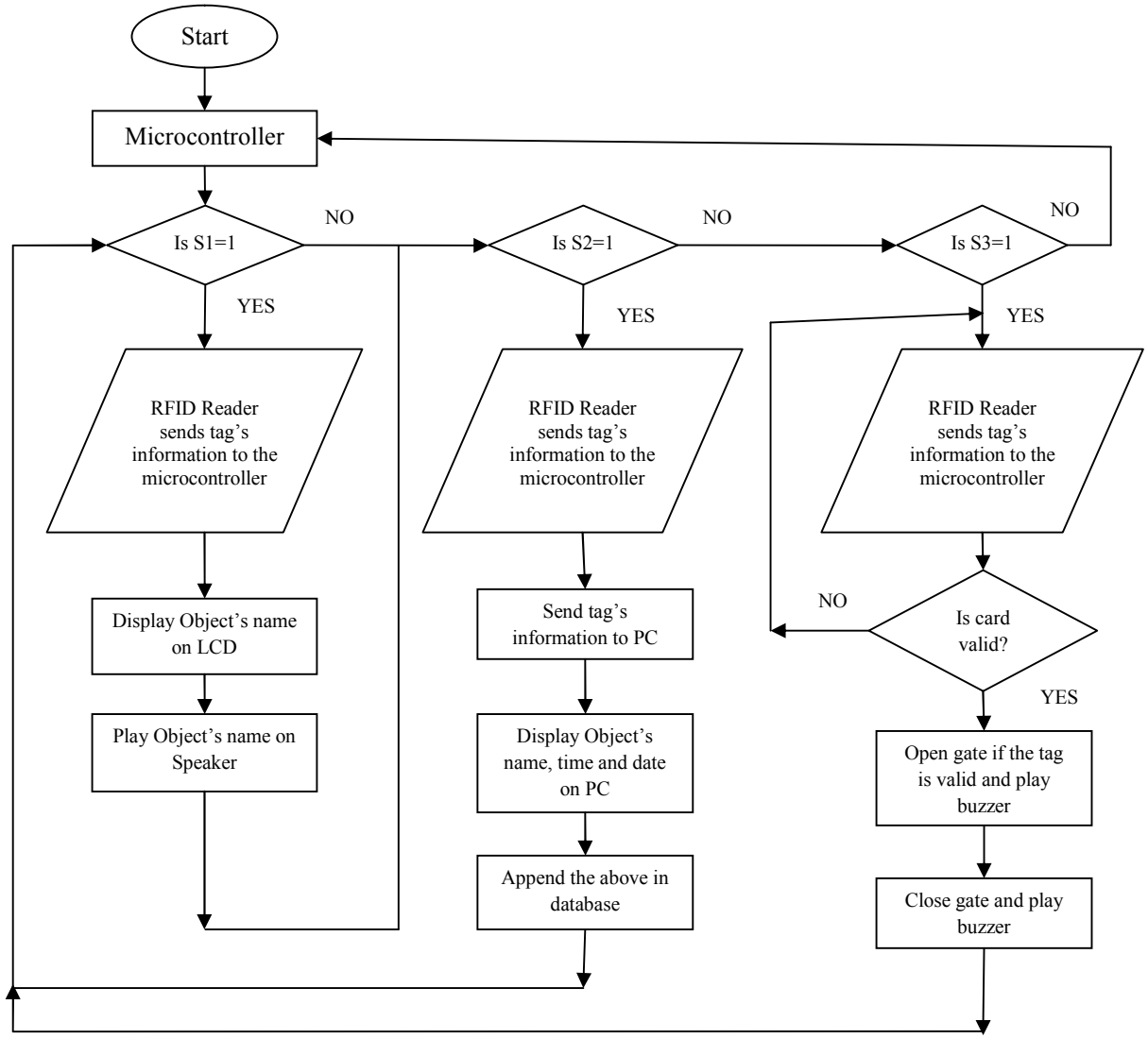


Fig. 3: Flow Chart of RFASSIST

This can also be implemented in security systems. When a valid card is identified only then gate is opened. The above system working has been represented by a flow chart, shown in Fig. 3.

Our RFID system comprises of an RFID reader working at 125 KHz and five passive RFID tags. These passive tags were placed on five different objects – Laptop, Mobile phone, CD, Remote Control and Book. The system utilizes an 8-bit PIC Microcontroller (PIC16F877A) especially designed for low- power operations. A further consideration is the selection of Microcontroller. Three different processors – AT89C51, PIC16F877A, and PIC18F4550 were considered and compared. The primary advantage of choosing PIC16F877A over AT89C51 mainly includes that it is a RISC design with low cost, inbuilt ADC, inbuilt comparator, powerful architecture, easy to use development tools like MPLAB IDE etc. PIC18F4550 is an advanced version of PIC16F877A. The former is suitable for our application.

In operation, the microcontroller receives the tag's information from RFID reader on receiver pin. When switch 1 is pressed and a tag is detected the microcontroller identifies the tag using tag id. A prerecorded audio message is played corresponding to the tag using APR9600 interfaced with microcontroller. Also the object's name is displayed on LCD. When switch 2 is pressed and a tag is identified, microcontroller transmits the tag's information to the PC. A database is created on PC using software code written in C Programming language. The database also records time and date of identification. When switch 3 is pressed and a tag is identified a gate is opened using relay operating at 9V. The relay is driven using ULN2004A. A buzzer is also heard which provides aid to the blind. After some delay gate automatically closes and again a buzzer is heard.

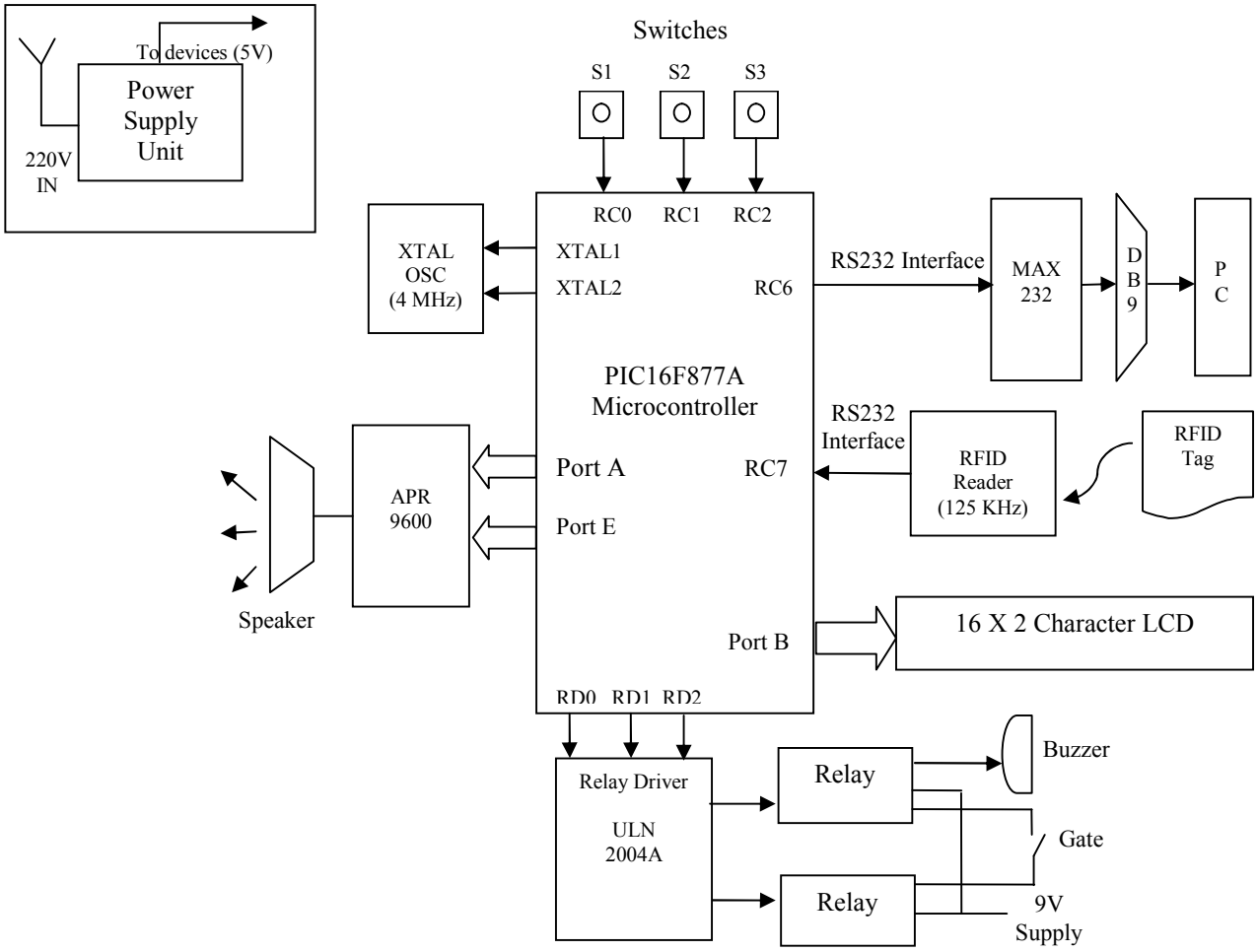


Fig. 4: Hardware Architecture of RFASSIST

Two types of communication are taking place in our system. One, in between the RFID reader and the microcontroller and other is in between the microcontroller and the PC. For both data transmission serial RS232 communication interface has been used. . Both the transmissions occur at 4800 baud rate. The Hardware and Software architecture of the system is shown in Fig. 4 and 5, respectively. Fig. 6 shows the hardware of the system.

4. EXPERIMENTS AND RESULTS

The output of the system is object identification. By using RFID tags one can evaluate system's performance. We are using 5 passive RFID tags. These RFID tags are placed on 5 different objects in an indoor environment- Remote Control, Book, CD, Laptop, Mobile. When a tag is detected, the three numbers printed on the tag is transmitted to the reader. One can use any of the three numbers to identify a tag.

When the number transmitted is same as that used by a microcontroller to identify an object, the following action takes place, if one of the three switches is pressed. Otherwise, no action takes place. When switch one is pressed the object's name is displayed on LCD and a message is also audible which assist blind people in object identification.

When switch 2 is pressed the data from controller is transmitted to PC. PC displays the date and time of identification in real time and also stores the entire information as a database. The file formed here is a MS Excel file. The code for this is written in C language. The PC display and the database are shown in Figure 7 and 8 respectively.

When switch 3 is pressed, upon correct tag identification, gate opens and a buzzer is heard. After some time gate closes automatically and again a buzzer is heard. To demonstrate this, a CD loader is practically used (as shown in Fig. 6). The actions are also displayed on LCD for reference.

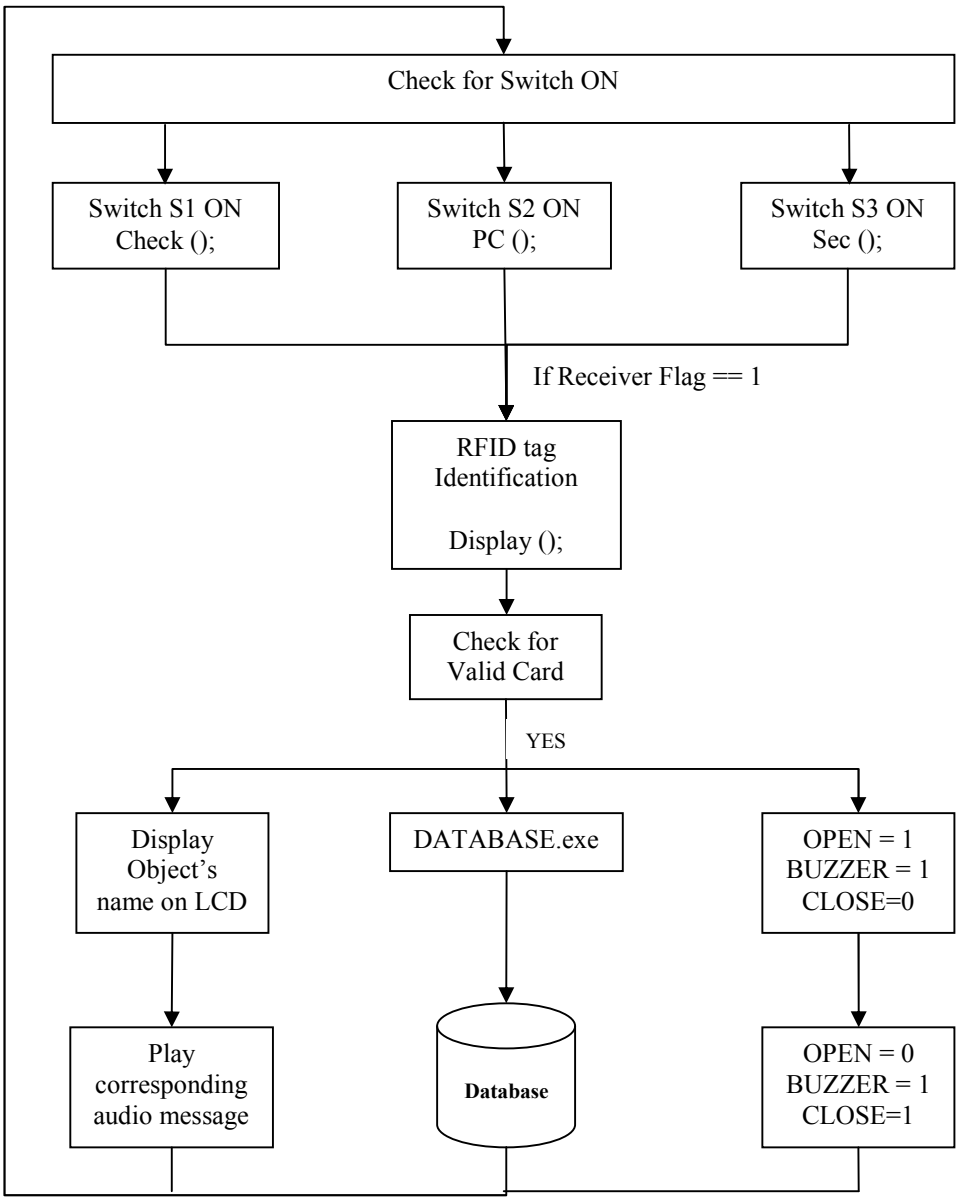


Fig. 5: Software Architecture of the system

Fig. 6: Full assembled PCB of RFASSIST (top view)

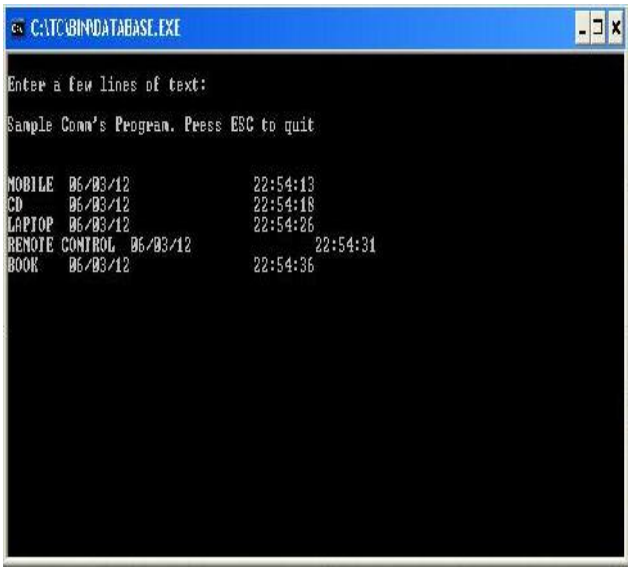
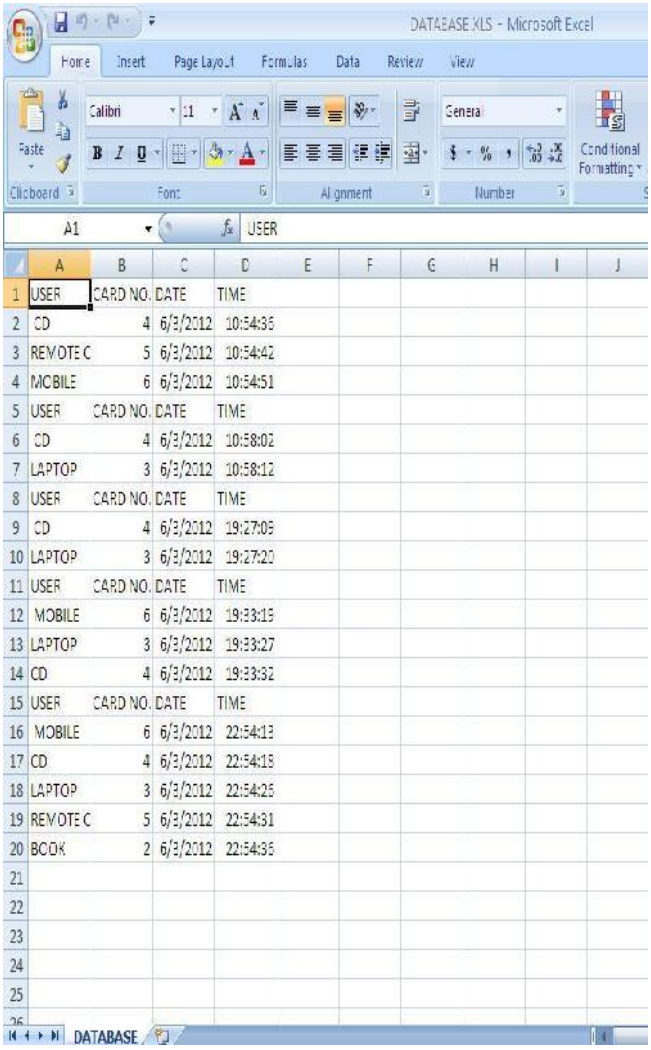


Fig. 7: Real Time display of date and time

Thus, the system is capable of identifying objects and the activities can also be stored in database for future referral. Undoubtedly it is very difficult for the blind to identify objects on their own. This system eases their work and provides audio messages which allow the identification of the object.

The prototype system presented here is a low frequency RFID system. This system was compared with an already existing low frequency RFID system. An RFID based attendance system is installed in BPIT College. Table I and Table II show the experimental results of the system as compared with existing RFID system.



	A	B	C	D
1	USER	CARD NO.	DATE	TIME
2	CD	4	6/3/2012	10:54:36
3	REMOTE C	5	6/3/2012	10:54:42
4	MOBILE	6	6/3/2012	10:54:51
5	USER	CARD NO.	DATE	TIME
6	CD	4	6/3/2012	10:58:02
7	LAPTOP	3	6/3/2012	10:58:12
8	USER	CARD NO.	DATE	TIME
9	CD	4	6/3/2012	19:27:05
10	LAPTOP	3	6/3/2012	19:27:20
11	USER	CARD NO.	DATE	TIME
12	MOBILE	6	6/3/2012	19:33:13
13	LAPTOP	3	6/3/2012	19:33:27
14	CD	4	6/3/2012	19:33:32
15	USER	CARD NO.	DATE	TIME
16	MOBILE	6	6/3/2012	22:54:13
17	CD	4	6/3/2012	22:54:18
18	LAPTOP	3	6/3/2012	22:54:26
19	REMOTE C	5	6/3/2012	22:54:31
20	BOOK	2	6/3/2012	22:54:36
21				
22				
23				
24				
25				

Fig. 8: Database of RFASSIST (DATABASE.xls)

Table I: Comparison of Read Range of RFASSIST with existing Attendance system

DATA	RFASSIST	ATTENDANCE SYSTEM
1	1.8 inch	1.2 inch
2	2 inch	1 inch
3	1.8 inch	0.8 inch
4	2 inch	1 inch
5	2 inch	1 inch
6	2 inch	1 inch
7	2.2 inch	0.8 inch
8	2.2 inch	1.2 inch
9	2 inch	1 inch
10	2 inch	1 inch

Table II: Comparison of Response Time of RFASSIST with existing Attendance system

DATA	RFASSIST	ATTENDANCE SYSTEM
1	0.9 sec	0.9 sec

2	1 sec	1 sec
3	0.9 sec	0.8 sec
4	0.9 sec	0.8 sec
5	0.9 sec	0.5 sec
6	0.9 sec	0.5 sec
7	1 sec	0.5 sec
8	1 sec	0.6 sec
9	1 sec	0.9 sec
10	0.9 sec	0.6 sec

The average of the data shows that the attendance system was capable of identifying tags from a distance of less than 1inch. On the other hand, RFASSIST can identify tags from a distance twice as that of the former i.e. approximately 2 inches. The response time was approximately same in both the cases.

Results show that the system is efficiently capable of object identification in short time for short distances. Also, the cost of developing the system was low as compared to others. The overall development cost of the system was Rs. 2500.

5. CONCLUSION AND FUTURE WORK

We presented a system that can easily identify objects for blind people using RFID, which would have been challenging for a vision only system. It makes use of low frequency RFID reader and passive tags. These tags operate wirelessly using power from RFID reader. They transfer the tag id to the reader and further to the microcontroller. Microcontroller makes use of this information to run various applications. It also displays object's name on LCD. Moreover, Database was also created. This would help in library management. This system can also open and close gate which would be used in toll and security systems. We developed a prototype system for the above. This system is not suitable for a read range that is required in object identification and toll systems to identify the tags placed on vehicles. To implement such system in real world, we need to replace LF RFID reader with HF or UHF RFID readers.

This system shows up excellent performance when a tag is identified. However, when multiple tags are used simultaneously, the system hangs. Also, there should be a small delay between two adjacent tag identifications. This limits system performance. But, the application for which the system is designed doesn't require simultaneous tag identification. The system is meant for blind people. They work at a slower pace as compared to us which provides sufficient delay between two events. Also, in toll systems when gate closes sufficient delay is there. When next vehicle enters the gate, the system is ready to sense another vehicle. Therefore, the above limitations do not affect our applications.

In future, the system would be capable of handling multiple tags simultaneously. Thus future design efforts will focus on improvements in simultaneous tag usage. The system would be used in future for location tracking as well. This would enable blind people to get location information and track objects. This would result in a complete package for the blind that could be used for multi applications.

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