

# Campus navigation for the visually impaired using Radio Frequency Identification

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**Abstract** --- In this paper we present a new system for helping visually impaired people in navigating around the campus buildings and rooms. The main idea behind the system is that it will aid the user in obtaining a more precise idea of their orientation while finding their way around the campus. The design consists of a simple Radio Frequency Identification Device (RFID) system that is based on data linking via electromagnetic waves. RFID transponders are strategically located around main entrances to each building, and also beside the entrance doors to all rooms within a building. An RFID transceiver picks up the signal that is closest to it, if any, and through the signal processing component sends it to the microcontroller. The microcontroller stores all information in a memory buffer, and plays an MP3 recording of a sound corresponding to a particular building or room number. The user is able to hear the sound through earphones.

**Index Terms** -- Microcontroller, Portable Radio Communication, Radio Frequency, RFID

## I. INTRODUCTION

VISUALLY impaired people have a fairly hard time finding their way around places such as a university campus. In order to address this problem, many efforts have been made that use a broad spectrum of technologies such as Infrared, Ultrasonic, Global Positioning System and many others. We propose a completely novel way of solving this problem using Radio Frequency technology. The design goal is to develop a simple and reliable device that will communicate with the user via audio sounds, indicating their approximate location.

The milestone portion of the project consists of two microcontroller evaluation boards, each connected to an RF transponder. The transceiver board is then interfaced with LabVIEW, where the system functionality is simulated in terms of interfacing with the user.

## II. DETAILED DESIGN

### A. Signal Reception

The front-end part of the RFID System is composed of three main components: a reader (transceiver), a tag (transponder), and a data processing system. Data linking and communication is made possible with the use of antennas on each device. All data is linked via the antennas, in the form of Radio Frequency (RF) electromagnetic waves.

The system uses two different types of transponders. Passive RFID tags are used inside the buildings. They require no power supply, but have a fairly short maximum communication range. On the other hand, active RFID tags are set up for building identification. Conversely, they require a small supply voltage, but have enhanced reading range.

The wireless communication that is achieved is based on magnetic coupling of two resonant circuits. These circuits are known as inductive circuits, and their frequencies are tuned to match each other as close as possible. This means that the transfer of energy from one circuit component to another occurs through a shared magnetic field. A current flow through one device will induce a current flow in the other device via the antenna. Therefore, the reader acts as a transmitter, the tag acts as a receiver, and the antenna acts as the coupling element.

Once the reader emits a magnetic field through its antenna, the transponder antenna picks it up. This induces a current in the transponder circuit, so that the transmission of the on-chip data can be started. The amount of current generated by the magnetic field of the reader is enough to power the entire transponder integrated circuit (IC) derives its clock source and power supply from the induced sinusoidal voltage on the antenna. This type of transponder is called a passive RFID tag. An active RFID tag has an additional small power supply.

### B. Parsing the RF Signal

Most RF transmitter and receiver modules [2] simply function by transmitting and receiving the signals that are specified in patterns of high and low square waves. Therefore, these RF modules are easy to implement with the Transistor-Transistor Logic (TTL) [1], as they can be specified to use 5V as a high signal, which is also used by our microcontroller. However, the TTL signals still need to be parsed for use in comparing with the database.

Similar to serial communication, the RF signals are separated into packets where there is a start and stop bit outlining the packet containing the ID Tag. A parsing system is implemented through software to buffer and filter the incoming data from the RF receiver. This is done in order to retrieve only the data containing the ID Tag and pass it along to the microcontroller.

### C. Database and MP3

An SQL database called UniversitySoeville has a table named Buildings with columns ID\_Number and BuildingName. The ID\_Number column acts as a primary key that contains 3-digit integer data that can be used to uniquely identify each row in the table. The BuildingName column contains variable length string data.

All the names of the existing building of the University of Soeville have to be ingested into the Buildings table of the UniversitySoeville database. It is a good idea to insert the building names alphabetically into the Buildings table when the table is

updated. Every time a building name is inserted, a unique ID\_Number is generated for it. This ID\_Number is one less than the ID\_Number of the building name before it. Note that our current design can only handle a maximum of 500 buildings, so the ID\_Number cannot exceed 500.

The UniversitySoeville database contains another table named Rooms with columns ID\_Number and RoomNumber. Again, the ID\_Number acts as a 3-digit integer primary key but it starts from 501 and ends with 510. The RoomNumber column contains a single digit integer data.

Each of the building names are converted and recorded into MP3 format. The naming convention of the MP3 files is very important. The MP3 filenames MUST start with a 3-digit number, which corresponds to the ID\_Number of the building that the MP3 file is attached to, and end with an .mp3 extension. All these MP3 files are stored onto a server.

#### D. MP3 Player

The visually impaired are informed about their orientation via an earphone. The sound that they hear lets them know what building or room they are adjacent to. These sounds are the MP3 files mentioned in Database and MP3 and they are all downloaded off the server onto a compact flash memory card that the device can read.

When the user is outside and is close to a building, the RF transceiver on the device will receive a valid RF signal. And the last 12 bits of this signal are used to determine where the user is. The 12 bits are treated as a binary-coded decimal (i.e. 3 sets of BCD) and it is converted into a 3-digit integer. This 3-digit integer corresponds to the ID\_Number of the Buildings table that corresponds to an MP3 filename. Knowing the filename of the MP3 file, any specific building MP3 file from the compact flash memory card can be played by the MP3 player.

When the user is inside a building, and is close to a room, the RF transceiver on the device will receive a valid RF signal. The last 12 bits of this signal are used to determine where the user is. The 12 bits are treated as a binary-coded decimal (i.e. 3 sets of BCD) and it is converted into a 3-digit integer. This 3-digit corresponds to the room number, so a building can have a maximum of 999 rooms. The 3-digit value is separated and 501 is added to each of them, so there are now three 3-digit numbers. The three 3-digit numbers correspond to the ID\_Number of the Rooms table that corresponds to an MP3 filename.

#### E. Device Features

The following features are available on the device itself, and can be seen in Figure 1 shown below: (1) Headphone Jack, (2) On/Off Switch, (3) Building/Room Mode Selector, (4) Automatic/Manual Mode Selector, (5) USB Socket, (6) Receive

Button, (7) Volume Control, (8) Belt Clip, and finally (9) Battery Compartment.

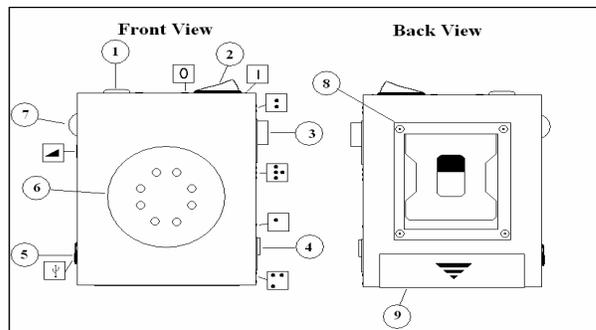


Figure 1: Portable Device Features

### III. DISCUSSION

Due to various types of losses that cause signal attenuation, the communication range of the transceiver-transponder pair is smaller than the wavelength of the signal between them. Since the distance over which the data is transmitted is smaller than one tenth of the wavelength in the worst case, design parameters such as scattering effects, impedance matching, and reflection coefficients will be ignored [3]. A schematic of the simplified RFID model is shown below in Figure 2.

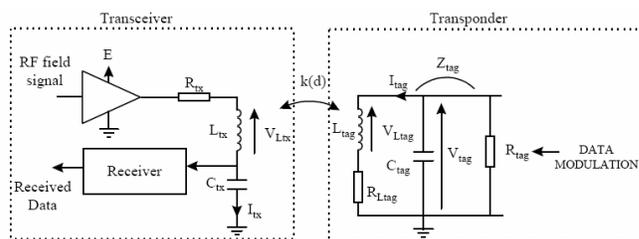


Figure 2: RFID System Equivalent Electrical Circuit

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