

# Security Hands Free Entry System

Anh Loan C. Nguyen, John E. Van Sickle,  
Jordan K. Acedera, Christopher Spalding

School of Electrical Engineering and Computer Science, University of Central Florida, Orlando, Florida, 32816-2450

**Abstract** — The project is to utilize radio frequency identification (RFID) and speaker recognition technology to create a security hands free entry system. The users will be able to walk up to the door with both hands preoccupied using the RFID card and voice to open the door. When the RFID card is within range, the user will speak a predetermined phrase of which will be compared to the voice profile on file. If there's a match, the user is accepted, and the door automatically opens. The design includes hardware and software which provides a functionality to allow the door to be controlled through the authentication of RFID card and voice by the microcontroller unit.

**Index Terms** — Access control, security, RFID card, 125Khz frequency, speaker recognition, automatic door.

## I. INTRODUCTION

In recent years the problem of home land security has attracted increasing attention and resources. The search for solutions that can guarantee greater independence and a better quality of security has begun to develop easily available state-of-the-art technology. Intelligent control systems, most called smart homes, smart environment systems, intelligent buildings, or intelligent homes can now be planned and would go far towards simplifying the interaction between difference technologies. A great number of benefits would stem from the implementation of such systems: greater safety, autonomy and self-esteem, and consequently, better relationships with others.

The proposed project is to utilize Radio Frequency Identification (RFID) and Voice Recognition technology to create a Security Hands Free Entry System. The Security Hands Free Entry System is motivated by the many times when people are hurriedly entering or leaving their residence as they are carrying groceries or boxes which may occupy the use of both hands. With the completion of this project, one will be able to easily enter a home or office even with both hands preoccupied. RFID Technology utilizing a 125 KHz proximity key will allow the user to unlock a lock within two feet (basic) from the door they are trying to open. The users will be able to walk up to the door with their key in their pocket and unlock the door without having to physically touch the key. The proximity key would replace manual keys, swipe cards. The proximity key design will work in

combination with voice recognition to ensure a higher level of personal security when unlocking the door. A user spends a few moments enrolling his or her voice in an application (creating a voice profile). Under normal operating conditions when the proximity key is within range, the user will be prompted by the application to speak a predetermined phrase of which will be compared to the voice profile on file. If there's a match, the user is accepted, and the door automatically unlocks. The door will remain unlocked for a pre-programmed period of time, and will return to the locked state at the end of the complete process.

Speaker recognition is one of the most widely used technological advances of our times. The technology has made a large progression to make it practical for commercial consumer use, such as, allowing those with disabilities the freedom to communicate with others. In this project, voice recognition will be manipulated to utilize the capabilities and functionalities of this technology. We plans to achieve this by combining the voice recognition technology with the 125 KHz proximity card access control system.

The system has four main subsystems: Card Access Control System, the Speaker Recognition System, the Electric Door Lock System and the PIC microcontroller. We use Card Access Control System, Speaker Recognition System, and an electric door locking system and combine all of them with PIC microcontroller acting as central control unit to make up a fully integrated security hands free entry system. In this modern time, maintaining personal security should be considered of the utmost importance. What if we lose the card key, what if someone recorded our voice? With this proposed solution it will take more effort for an adversary to obtain the card key and the voice at the same time.

The security hands free entry system is simple and straightforward. It is designed so that it is self-explanatory in its operation and simple for anyone to use regardless of their educational background even the people that are not as technologically oriented should be able to use the system with much ease. Any technological device should be to facilitate certain aspects of life and not make matters more complicated.

## II. THE SYSTEM DESIGN

The Security Hands Free Entry System consists of hardware and an application program for microcontroller unit developed in Hi-Tech C programming language and MCU voice recognition. The hardware module has four main subsystems. We will cover these four subsystems in more details throughout this section. The four main subsystems include:

- Card Access Control System

- Speaker Recognition System
- Electronic Door System
- PCB PIC Microcontroller.

The control action is actually performed by the microcontroller. It processes the signals that are inputted from the valid card reader and voice signal at the entrance. The output section of the microcontroller is connected via relays circuit for the desired operational action. The completed hardware system is shown in figure 1.

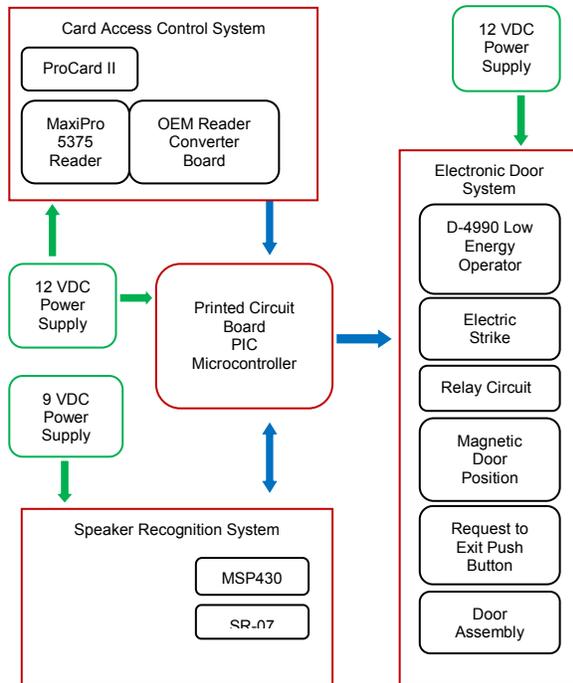


Fig. 1. General Hardware Design Block Diagram

### III. CARD ACCESS CONTROL SYSTEM

The Card Reader access control system shall provide the ability to regulate access the door through PIC microcontroller. We use MaxiPro 5375 for card reader, Prox card II and Wiegand converter for reader controller interface. These entire products meet our requirement of our product which is the reader can read the card at least 2 feet range. The completed card access control system is shown in figure 2.

#### A. ProxCard II

Proximity is an access control/identification technology that utilizes radio frequency (RF) circuits in microchip form. The microchips are encoded and transmit the encoded information when activated. The proximity card is used with its associated proximity card readers.

The RF-programmable Proxcard II is compatible with all HID proximity readers. ProxCard II is offers extremely

consistent read range and unaffected by body shielding or variable environment conditions, even when close to keys and coins. Using ProxCard II with MaxiProx reader can produce read range up to 24 inches. The ProxCard II requires a minimum of 5VDC for operation and will accept up to 16 VDC input. It draws an average of 35 mA at 12VDC and has a peak current draw of 125 mA. Cards has encoded as 26 bit Wiegand to utilizing proximity technology. The card can fit into wallet or purse. It is light weight, strong, flexible and resistant to breaking.

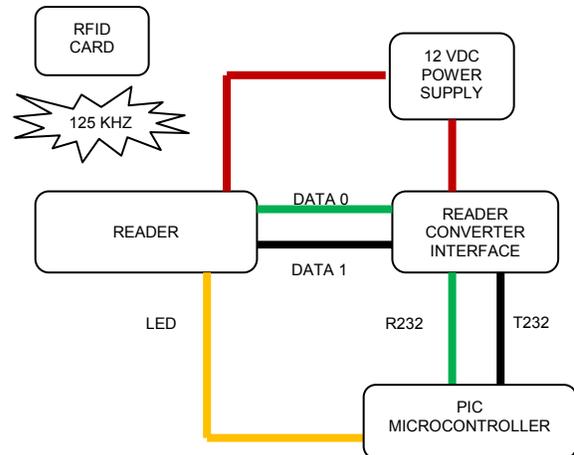


Fig. 2. Card Access Control System

#### B. MaxiPro 5375 Long Range Reader

The Reader is used to activate the passive tags with RF energy and extract information from these tags. They contain a transmitter, receiver, and digital control module that interface with the operator interface. The reader interfaces with its antenna via an interface chip. If a tag is sensed by the antenna, the reader will transmit the data to controller. The controller will decode the data and pass it to the operation interface where is programmed to lock or unlock the door. The ability to read a tag from much a greater distance requires much more complicated receiver circuitry and the ability to generate a higher power RF magnetic field. Each reader can only talk to its corresponding card type since each of the technologies is unique. For HID Proximity 125 kHz, MaxiProx 5375 Reader is ideal for long read range applications. It has long read range distance up to 6 feet (with ProxPass). MaxiProx is easily interfaced with all existing Wiegand, Clock—and –Data, RS-232, RS-422, and RS-8485 protocol access control system [1].

#### C. Reader Converter Interface

The Wiegand interface is the wiring standard used to connect access card mechanisms and other security devices to electronic entry systems that read the input

information. In the Wiegand mode the serial port is able to receive the data directly from any Wiegand device, such as card reader and also output the data in the Wiegand format, as if it was a card reader itself [2]. Wiegand interface is popular in the security, access control, and automation industry. The OEM Wiegand converter requires a regulated power source of 5 VDC or 8-16VDC, 100mA for internal operation. The RS-232 communications parameters are: 9600 baud, N no parity, 8 data bits, 1 stop bit and no hardware flow control [3].

Wiegand converter operates with any card reader that produces a standard Wiegand (Data 1 / Data 0 or Clock and Data) communication output. Wiegand format is easy to use, no need to deal with clock. We have designed to pick out Wiegand format to get data from card reader and then convert Wiegand data transmit to PIC controller via RS232 connector. A 26 bit Wiegand format will be used in the example below.

Input: Wiegand (26-bit)

1 001011010100101100011010 1

Even Parity Data Odd Parity

Output: 16-byte ASCII string from RS232 method

\* 26 # 00002D4B1A 3 CR

26-bit Wiegand Data ((2D4B1A<sub>hex</sub>) Parity Character

#### D. Power Supplies

Power Supplies for hardware designed specifically for the system equipment installed. The MaxiProx 5375 reader requires a linear power supply with a rating of 24 - 28.5 Volts DC at a minimum of 1.5 Amps per reader. A linear power supply aids maximum reader performance. The Wiegand converter requires a regulated power source of 5 VDC or 8-16VDC, 100mA for internal operation. The reader and reader converter interface has shared 12VDC power supply. RFID card utilities power from the reader through radio frequency.

## IV. THE SPEAKER RECOGNITION

Simply put, voice recognition is the act of recognizing an identified speaker's speech and converting it into text. In particular, voice recognition systems have to be trained to a specific user, combining the principles of both speaker recognition (identifying the speaker) and speech recognition (determining what words the speaker is saying). The development of voice recognition systems, especially their training methods, is mostly due to the fact that human speech patterns vary from person to person. Accents, in particular, cause these differences to emerge in basic speech recognition systems, causing them to behave in ways not intended. The key difference between the two components to voice recognition is that speaker recognition is the process of recognizing the identity of the speaker whereas speech recognition is the process of

determining what is said by a speaker. We will be using speaker recognition methods. The basic operation of speaker recognition is shown in figure 3.

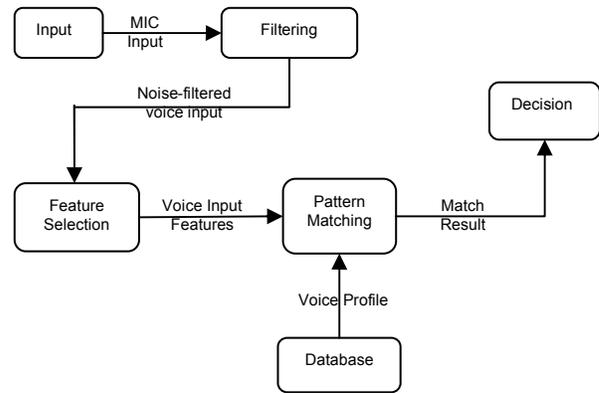


Fig.3. Basic Operation of Speaker Recognition

#### A. Texas Instrument MSP430

The Texas Instruments MSP430 Ultra-Low Power MCUs are known for their ease of use and low power consumption. A microcontroller is necessary to interface the PIC subsystem with the Scientific Instruments Speech Recognition circuit SR-06. The microcontroller and SR-06 collectively handle user profile management.

#### B. Images Scientifics Instruments (SI) Speaker Recognition Circuit SR-06

The SI SR-06 circuit is an unassembled speech recognition circuit. An alternative is the SR-07 speech recognition circuit, which provides the exact same functionality as the SR-06 but comes fully assembled. Consequently, the SR-07 is more expensive, so for the purposes of cost-effectiveness we used the SR-06 speech recognition circuit. Both circuits utilize the HM2007 speech recognition IC. It is a speaker dependent chip capable of recognizing up to 40 .96-second words or 20 1.92-second words [4].

#### C. Voice profile

Voice profiles, as stated earlier, will be collectively managed by the combination of the MSP430 MCU and the SR-06 Speech Recognition circuit. User identification will be hard-coded into the MCU based on the passphrase location the user selects on the SR-06. Program flow for speaker recognition can describe as follow:

The MCU receives a 3-bit user ID from the PIC. The speaker then speaks into the SR-06. The SR-06 will recognize the word as one of twenty possible words from its memory. The SR-06 will then send the value of the word (either 1 through 20) as a 6-bit output to the MCU. The MCU will then compare the value from the SR-06

with the user ID received from the PIC. If the value and user ID match, a 3-bit confirmation code is sent to the PIC to confirm a match. If a match is not made, a bit sequence of all zeros (000) will be sent to the PIC.

#### D. Speaker Recognition System Power Supply

The SR-06 requires a 9V power supply, which comes in the form of a standard 9V battery. This poses the problem of prolonged use; initial testing shows the battery can only last for a few hours while the circuit is on standby. We can easily remedy this by replacing the battery with a 9V power supply.

For the purposes of our demonstration, we will continue to use the 9V battery, however. Should we decide to further develop our prototype, we will switch to a constant 9V power supply.

### V. ELECTRONIC DOOR SYSTEM

The Electric Door System shall provide the ability to open the door without having to insert a key and turn a knob utilizing industry standard hardware utilizing proven technologies. The completed door hardware system is shown below.

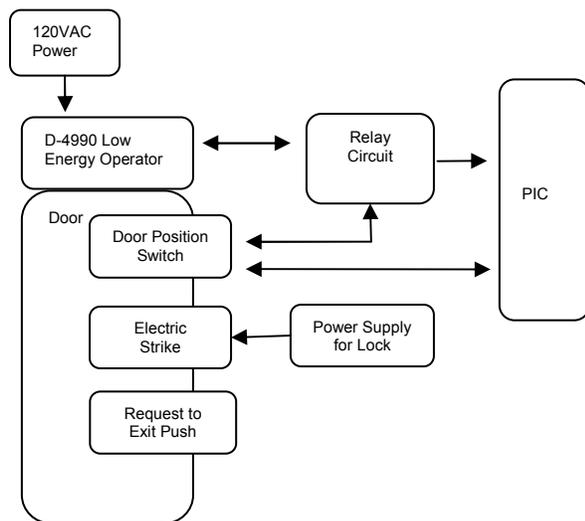


Fig. 4. Electronic Door System Block Diagram

#### A. D-4990 Low Energy Operator

The D-4990 Low Energy Operator is an electro-mechanical product designed to provide safe and convenient automatic access. It is a "Power Open" operator that can be activated with the press of a switch. It can be used with electric strike. A time delay function is built into the control system eliminating the need for supplemental relay or controls [5].

#### B. Electric Strike

Electric strike is also called electric latch release they replace a standard strike mounted into the door frame and receive the latch and latch bolt. It has a drop away side that as energized moves out of the way of the door mounted lockset. Latches are set to default as either lock safe or lock secure. This is the mode that the lock would be in if the power were lost [6].

#### C. Request to Exit Push Button

The user may desire to exit the interior while utilizing the electric strike. This push to exit switch enhances the operation of the system by allowing minimal contact. The voltage range of request to exit push button is 11.6-28.5VDC. Requirement for a door exit application would be a N.O. or Normally. Request to exit Push Button shall be surface wall mounted about 48" above finish floor on the interior side of the door.

#### D. Magnetic Door Position Switch

The magnetic door position switch is an invisible sensing device. It is used to monitor the status of the door. The magnetic door position switch is activated when the door is moved from a closed position.

#### E. Door Relay Circuit

A simple relay circuit has used to communication between the door and PIC microcontroller unit. It is a switch to turn on and off connection between PIC and door. The door relay circuit is shown in figure 5.

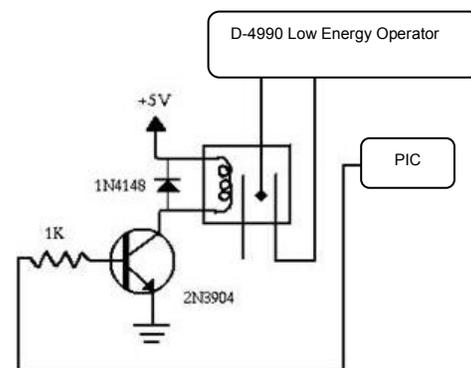


Fig. 5. Door Relay Circuit Block Diagram

#### F. Door System Power Supply

A wall mounted step down transformer of the 500 VA rating was determined to be best suited for our application. This size will insure future addition of options to include status buzzer and perhaps lights. This particular design is readily plugged into the wall not requiring a dedicated circuit.

## VI. PIC MICROCONTROLLER

The PIC subsystem is responsible for tying together all of the other independently functioning subsystems and providing the desired functionality to the project as a whole. The PIC follows a logical sequence of events in order to provide the desired high-level functionality of the total system. The PIC's program includes several built-in interrupts to adjust to the status of the door throughout the basic sequence of events.

### A. PIC 16F877A

The Microchip PIC16F877A microcontroller is the centerpiece of the PIC subsystem and really the project as a whole. Without the microcontroller, none of the other subsystems would function as they are supposed to function. In terms of hardware, the PIC16F877A shares an electric connection with virtually every other aspect of the project. Many of these components operate at higher voltages than the microcontroller and carry larger currents; careful consideration had to be given in designing these connections. The PIC16F877A operates at frequencies up to twenty megahertz, voltages in the range of 2.0 V to 5.5 V, and currents as high as two hundred and fifty milliamps [7].

The microcontroller's connection to the programmer is the only connection to a peripheral device that will not utilize a terminal block. Instead of a terminal block, six 0.025" square pins with 0.100" spacing will be used to connect to the programmer. The six pins that make up this connection are designated as  $V_{PP}/MCLR$ ,  $V_{DD}$  Target,  $V_{SS}$  (ground), PGD, PGC, and auxiliary. The  $V_{PP}/MCLR$  pin provides voltage for programming and master clear functionality. The pin will connect to the  $V_{PP}/MCLR$  pin on the microcontroller through a series of capacitors and resistors as indicated by the programmer's data sheet. The  $V_{DD}$  pin and the  $V_{SS}$  pin will be connected to their respective pins on the microcontroller. The PGD pin will connect to port B at pin seven, while the PGC pin will connect to port B at pin six. These pins on the microcontroller provide special functionality for in-circuit programming. The auxiliary pin will have no connection to the circuit; however, it will still be included since there is a specified port for it on the programmer.

The programmer will connect to the printed circuit board by plugging the programming connector into the square pin connectors mounted on the board. A USB cable will be used to connect the programmer to a computer. A hex file is used to program the microcontroller. The hex file will be generated from C code by the HiTech C Compiler. The programmer includes software that will be used to burn the generated hex file into the microcontroller's memory. Once the microcontroller is successfully programmed, the file will remain in the

microcontroller's memory until the PIC is erased using the programmer software or a new program is loaded into memory. The programmer can be disconnected from the printed circuit board once programming has been verified and it is confirmed that the device has been successfully programmed. The specific connections for each subsystem are provided in detail below.

### B. PIC and Card Reader System Integration

The microcontroller will connect to the card reader subsystem via a simplified RS-232 protocol connection that does not require a physical RS-232 connector. A simple terminal block will be used in place of the RS-232 connector. Because the PIC and reader converter board do not operate at the same voltage level, a signal converter was necessary to facilitate communication. The reader converter board transmits the card ID via the RS-232 protocol. The MAX232 converts the signal to a TTL format and forwards the converted signal to the microcontroller. The PIC also draws its power supply from the reader converter board, so voltage and ground connections were also necessary.

### C. PIC and Voice Recognition System Integration

The microcontroller will share a six-pin connection with the speaker recognition subsystem. Three pins will be reserved for output to the speaker recognition subsystem, while the remaining pin will be maintained for input from the speaker recognition subsystem. The speaker recognition subsystem will support up to six unique voice profiles. The output pins will be used to communicate which of the six voice profiles is trying to be matched depending on which card is in range of the reader. The voice profiles will correspond to three-bit binary outputs '001' through '110.' An output of '111' will indicate that no match is trying to be made because there is not a valid card in range of the receiver. The input pins will indicate the result of the attempted voice match. If the presented voice does not match the stored voice in the profile, a value of '111' will be sent to the microcontroller indicating a mismatch. If a positive match is made between the presented voice and the stored voice, a value equal to the voice profile ID will be sent to the microcontroller indicating a match. All of these connections will be made with the microcontroller through a six terminal block. The output pins will be tied to port E, while the input pins will be tied to port D.

### D. PIC and Door Lock System Integration

The microcontroller will communicate with the electric door latch subsystem in a number of ways. First, the microcontroller will share a two-pin connection with the door status switch of the electric door latch subsystem. One pin will be designated for output, and the other pin

will handle input from the switch. These connections will allow the microcontroller to keep track of whether the door is locked or unlocked as any given time. These connections are necessary because locking the door after entry is handled internally by the electric door latch subsystem rather than directly by the microcontroller. The microcontroller shares an additional one-pin connection with the electric door latch subsystem that handles unlocking the door. When activated, this connection will effectively close the circuit of the electric door latch subsystem allowing it to unlock the door for a specified amount of time. The final connection between the microcontroller and the electric door latch subsystem is a ground wire to provide a common ground between the five-volt power supply of the microcontroller and the twelve-volt power supply of the electric door latch subsystem. These connections will be made with the microcontroller through a four terminal block with three of the terminals tying into port A on the microcontroller and the remaining terminal connecting to ground on the printed circuit board. The push to exit button shares no direct connection with the microcontroller. The microcontroller will only know that the button has been pressed through its connection with the door status switch.

#### E. The PIC Control Program

In order to provide functionality to the microcontroller, it needs to be programmed. The process of programming a PIC is often referred to as “burning.” A hex file is required for burning into the PIC. It is possible to program the hex file directly, but for the sake of simplicity, a compiler is often used to generate the file from code written in a more user-friendly language. There are several C compilers available for programming PICs.

The PIC control program can be written using a low-level assembly language or high-level language such as C or Java. A compiler for high-level language helps to reduce production time. The PICkit2 Microcontroller Programmer is developed by Microchip, the same company that develops the PIC16F877A used for this project. The programmer package contains the PICkit2 Development Programmer/Debugger, the PICkit2 Programming Software, a USB cable, and lessons for programming PIC microcontrollers. The programmer uses a USB mini-B connector to connect to a computer and a 6-pin programming connector to connect it to the target device. The 6-pin programming connector accepts 0.025” square pins with 0.100” spacing. In order to connect the programmer to the microcontroller, it will be necessary to mount a 6-pin male header connector on the printed circuit board. The source code has been commented to facilitate any occasional future improvement and maintenance. The code written followed all the three steps of microcontroller program development that is: Compilation, Burning and

Evaluation before it was transmitted to the microcontroller through the programmer.

#### F. Stage Diagram:

Figure 6 shows the various states that the system can take and the actions necessary to proceed through them. There are five basic states of the system: waiting for card, waiting for voice, card and voice confirmed, door opened, and door closed. The function of the microcontroller will vary depending on the state of the system. Certain actions will be expected when the system is in one state, while those same actions will be completely ignored by the microcontroller if they occur while the system is in another state. A brief description of the five states of the system as well as the actions that facilitate changes in state and state diagram is provided below.

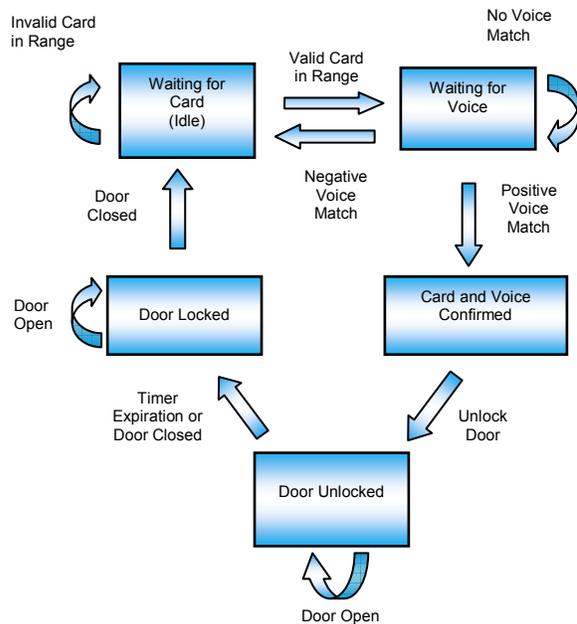


Fig. 6. PIC State Diagram

The “Waiting for Card” state is also referred to as the idle state. This is the state of the system when it is not currently in use. The system will remain in the “Waiting for Card” state until a card comes in range of the receiver, and the card reader subsystem transmits the card identification to the microcontroller. If the card’s identification is not among the short list of cards to be used by the system, the card will be identified as invalid. No state change occurs when an invalid card is in range of the receiver. However, if the card’s identifying information is found in the system, the card will be deemed valid. When a valid card is in range of the receiver, the system will proceed to the next state in line, the “Waiting for Voice” state.

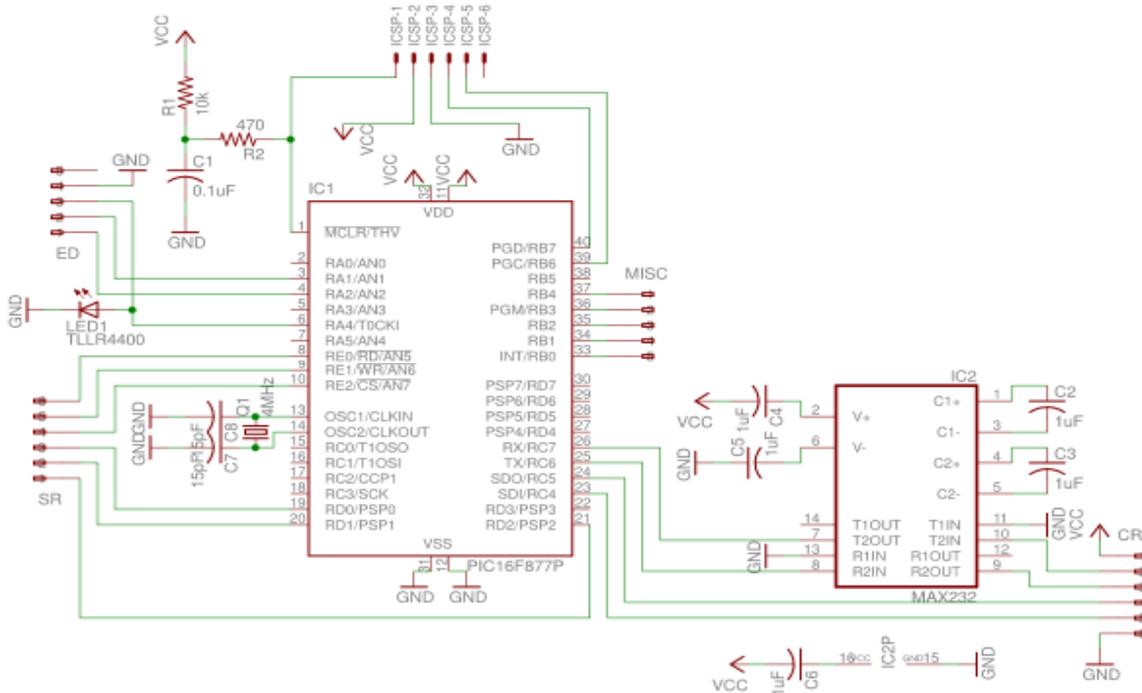


Fig. 7. PCB Schematic

The “Waiting for Voice” state is the second possible state of the system. During this state, the microcontroller is communicating with the speaker recognition subsystem. The system will remain in the “Waiting for Voice” state until some kind of voice match is made. If a negative voice match occurs during this state, the system will revert back to the “Waiting for Card” state. However, when a positive voice match is made between the presented voice and the voice profile, the system will then proceed to the next state in the sequence, the “Card and Voice Confirmed” state. This state will cause a cascade of signals that function to open the door. The system will then enter the “Door Unlocked” state for a short while. The system will then progress to the “Door Locked” state until the door closes, and the cycle begins again.

### G. Printed Circuit Board (PCB)

A printed circuit board is necessary to facilitate communication between the PIC system and every other aspect of the project. The microcontroller will be mounted on the printed circuit board, which will electrically connect the microcontroller to other electronic components via conductive pathways. Electrical components are attached to the surface of the printed circuit board by soldering. The EAGLE PCB software has been used to create the circuit for the project. The PIC schematic layout is show in figure 7.

### H. PIC Microcontroller Power Supply

The PIC16F877A will accept voltages in the range of 2.0 V to 5.5 V with frequencies as high as 20 megahertz.

The microcontroller will connect to the five-volt power supply via a terminal block, the same way it connects to each of the subsystems. This will provide more versatility than if the power supply were mounted on the board directly. It makes replacing the power supply easier in case it malfunctions. A dedicated external power supply was considered for the PIC microcontroller. However, it made more sense to use a regulated power signal from the reader converter board. There is no need for separate power supplies because the function of the microcontroller relies on receiving data from the card reader. If the power supply to the card reader fails, the microcontroller will not be able to function properly. It makes sense that these two subsystems share the same power supply.

## VII. THE SYSTEM OPERATION

After the system is turned on, the door indicator’s light emitting diode (LED) come ON after some few seconds, indicating that door is in the ready state. On the secure side of the door, red LED is normal status of reader and voice panel. Person approaches to RFDI range with the valid RFID card, the LCD green’s reader will flash and beep once (reader control not from PIC) to indicate that PIC has acknowledge first identification, then green LCD on voice panel will turn on, indicated that system need the second identification which is the voice data. Person is going to speak his/her password. Once both data have matched with memory data, then PIC will release the door contact. The solenoid release with the click sound, door is opened and both LCD turn red, ready for next identification.

If the voice profile doesn't match the system, PIC will command LEDs on reader and voice panel turn red which is normal condition, no action to the door. The RFID card will timeout in about 5-7 second if there is no action which is repeated wrong voice profile. The system is waiting for the next card in range. If the reader did not recognize the valid card in the first place then nothing happen, no action follow up for voice active either. Reader works as the filter to activate the voice system.

After the person gets in to the unsecure side, the door will close and lock by hearing a solenoid' click. On this side, we have designed a request to exit push button. Once the button is pressed, door will open, following a click sounding from the solenoid. For any others complicate operation, it can happen but it should be consideration for the future design.

### VIII. CONCLUSION

This project, being a heavily involved group initiative, required that each person achieve their individual goal and responsibility. The project has successfully presented a functional and low complexity microcontroller based on voice recognition and door access control system. We accomplished what we set out to do, make a hands free door open and closed with the feature of RFID card and voice recognition. A real-life equivalent of the design can be developed where high security is required.

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### BIOGRAPHY



**Anh Loan Nguyen** is currently a senior Electrical Engineering at the University of Central Florida. She will be completing her Bachelor Degree in fall 2012. After graduation, she will continue her career path working for HDR Inc.



**John E. Van Sickle** is currently a senior Electrical Engineering at the University of Central Florida. He will be completing his Bachelor Degree in May 2012. He plans to pursue his Master's in Business with future plans towards a PhD in an emerging technology in electro-optics, bio-nanotechnology.



**Jordan K. Acedera** is currently a Computer Engineering undergraduate student at the University of Central Florida. He will be completing his Bachelor Degree in Computer Engineering this semester.



**Christopher Spalding** is a senior Computer Engineering student at the University of Central Florida. After earning his Bachelor Degree in Computer Engineering, Christopher will begin his graduate studies at the University of Louisville School of Medicine.