Log on to Living Smart Room via Bio-Capsule

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Abstract – The project is a smart room system that would adjust the room lighting and temperature settings according to the users’ preferences. The system identifies different users through the RFID technology. Each user carries his or her own RFID tag. The antenna placed at the room entrance would sense the tags and interact with the RFID reader to identify the users present and adjust the environmental settings when the users come into or leave the room.

Keywords – RFID, bio-capsule, microcontroller

I. INTRODUCTION

1.1 Purpose and Usefulness

Since RFID technology provides a convenient lightweight identification mechanism, the idea of smart room becomes more practical and marketable. Currently, there are many technologies used to create a better living environment, however, most of them requires actual contacts and are usually hard to configure. The idea of smart room is a direct approach to make everyday life easier, more convenient, and, most importantly, free of hassles. The core philosophy of this project is to provide a system that follows one’s preference exactly the way one wants it.

1.2 Project Functions

The intent of this project is to create a smart room using RFID technology. One will carry a name-card sized RFID transponder in one’s purse or wallet. Whenever the RFID tag gains adequate power from the antenna, it will transmit a specific ID to the RFID reader. The RFID reader will communicate to a microprocessor, which controls the room settings based on the ID information. Each ID will have its own user preferences for room lighting and temperature. The microprocessor will act as thermostat and automatic light switches.

If two or more people enter the room at the same time, the room settings will change based on a priority system, which user number 1 gets the first priority and so on. The user with the highest priority will have say on the room conditions.

There will also be a color LCD monitor and user input pad coming with the system so that the users can change the settings easily through the two devices.

1.3 Specifications

The RFID reader used in this project is Skyetek M9, which is a tiny, embedded UHF RFID reader module with operating frequency range 862-955 MHz. This device is able to sense anyone carrying a RFID transponder within 50cm from the location of antenna with a 5 to 10 Hz self-refreshing rate. It also requires the targeting subject to carry the RFID transponder in acceptable orientations and to pass by the antenna in specified movement pattern. The device should only operate under normal conditions such as temperature of range -20°C to 80°C. Additionally, the thermal component will be able to sense temperature ranging from -40°C to 125°C with an accuracy of less than ±1.5°C.

1.4 Blocks/Subprojects

The project is broken into several blocks/subprojects as described below. The block diagram can be found in the appendix.

1.4.1 Passive RFID Tags

Passive RFID tags are chosen for this project. Each of the system users will have their own RFID tag, which will interact with the RFID reader through the antenna. Each tag will have its own unique “identification number” for the system to identify which person and to adjust the room settings for each specific person. Whenever the RFID tag gains adequate power from the antenna, it will transmit a specific ID back to the RFID reader.
1.4.2 Antenna

The antenna connects to the RFID reader and works as the communication “bridge” between the RFID tags and the RFID reader. The RFID reader transmits the signal and alternating power wave and receives the feedback from the RFID tags. This project plans to use two antennas at the doorway to help the system in detecting the movement direction of each user.

1.4.3 RFID Reader

The RFID reader will be communicating with the microcontroller through RS232 interface. The RFID reader provides the power for RFID tags and receives the feedback from the RFID tags through the antenna. The reader will then pass the information to the microprocessor for further processing. Although the RFID reader is capable of programming the information inside RFID tags, such a feature will not be used in this project.

1.4.4 Temperature Sensor

The temperature sensor will be placed near the microprocessor with access to the room environment. It detects the current room temperature actively and outputs the figure to the microcontroller. The output from the temperature sensor is a digital output, and the communication between the sensor and the PIC is through SPI.

1.4.5 Microcontroller-AT89C51

The microcontroller will be the heart of this system. The settings of all users will be stored in the memory of this microcontroller and it will scan through all inputs to determine adequate outputs in a timely fashion. It receives the information from the RFID reader, the temperature from temperature sensor, and the logic input from user input pad. It determines all the outputs for temperature switches, lighting switches, and commands for RFID reader based on relative inputs. Most importantly, the microcontroller generates graphic display outputs to the LCD continuously. The microcontroller will be utilizing its internal timer to initiate most processes.

1.4.6 User Input Pad

The user input pad is the only manual input interface to the microcontroller. It is composed by six buttons with the function of up, down, left, right, enter, and cancel. It provides the users full control over their preferences and relative settings.

1.4.7 Color LCD

The LCD display is the communication medium between the system and the users. The system will convey the information to the users through the LCD. The LCD will be interfacing with a parallel-load multi-bit serial transceiver, which connects to the microcontroller.

1.4.8 Lighting / Temperature Switches

The microcontroller controls all the lighting and temperature control switches. The on and off for the switches changes based on the desired lighting and temperature settings stored in the microcontroller by different system users. The temperature control switches include switches of different temperature related devices (i.e. fans, heaters).

1.4.9 Power supply

This project will require a power supply with different output voltages for different components of the system. The RFID reader and the main circuit needs a 5V DC supply, the LCD backlight requires a 6 to 7 V DC supply, and the LCD logic will need a 3.3 V DC supply.

II. TESTING

2.1 Antenna Test

Several different tests were performed on performance of the RFID reader and antenna. The tests included repeatability, signal distance, various tag angles and positions, and different Antennas. We also placed the RFID tag in a wallet to test the performance because that will be the practical case when the system is used in real life.

2.1.1 Main Distance test
The main antenna detecting distance test is performed by placing the RFID tag in the front side of the antenna with the tag parallel and perpendicular to the arrow mark on the antenna. By comparing figure C.1 and C.2, it is clear that when the RFID tag is placed as condition 1, it has a better performance and greater detection range than condition 2. From figure C.1, one can see that the performance is good until the distance reaches about 50cm, and then the performance starts to decrease as the distance increases.

2.1.2 Test on Different Sides of the Antenna

The tests were performed on the different sides of the antenna. As shown in figure C.3 and C.4, it can be seen that the performance and the detection range on the shorter side of the antenna (condition 1) were both worse than those on the longer side of the antenna (condition 2). Although the longer side of the antenna gave a better performance than the shorter side of the antenna, its performance and detection range were still worse than the front side of the antenna (refer to figure C.1).

2.1.3 Test on Tags Placed At Different Angles

The test was performed with the RFID tags placed at different angles to the antenna. The test result can be found on figure C.5 and C.6. As shown in figure C.5, in condition 1, the antenna had similar performance while the tag was placed at 30 and 60 degrees to the antenna. Both of the performance were better than placing the tag at 0 degree (refer to figure C.3).

From figure C.6, it can be seen that in condition 2, while placing the tag at 30 degrees to the antenna, the antenna has a more stable performance than that of placing the tag at 0 degree (refer to figure C.1).

The conclusion of the angle tests was that the antenna works more stably while the RFID tag was read from an angle.

2.1.4 Test on RFID Tag Placed In a Wallet

The RFID tag was placed in a wallet and the performance of the RFID reader was tested. It was found that the reader has better performance within a distance of 14 centimeters. It can hardly read the tag when the distance is greater than 14 centimeters. The result can be seen on figure C.7.

2.1.5 Tests on Different Numbers of RFID Tags Read At the Same Time
The performance of the RFID reader was tested with different numbers of tags placed at the same distance in front of the antenna. The number of success here indicates the number of times that all the tags are read by the reader.

From our testing results (refer to figure C.8, it was found that the performance of the reader drops as the distance from the antenna increases. And the more numbers of tags read at the same time, the worse the performance of the RFID reader. The maximum detecting distance also decreases as the number of tags increases.

2.1.6 Test on a Different Antenna

Tests were run on the antenna that is designed for the Texas Instrument RFID reader with 13.5 MHz frequency. The reader could still read the RFID tags through the antenna, but it could only do it within a very short distance (within 5cm), and the performance of it was not very good as showing on figure C.9.

2.2 Function Test

Several tests were performed to test the functionality of the system. The tests performed included the input/output test, temperature measurement test, user identification test, and the overall function test.

2.2.1 Input/Output Test

Several tests were performed on the user input pad and the output relay switches. Each of the input buttons was tested separately, and each of them worked properly. The LCD screen was able to change according to the command inputted from the input pad. The MC14490 debounce chip also worked well as no bouncing phenomenon occurred when the test was performed on the input pad. The output relays were able to turn on the LED when a high was outputted from the PIC.

2.2.2 Temperature Measurement Test

Several tests were performed on the temperature sensor to test its accuracy and the ability to response to the change of environment temperature. The temperature output from the TMP121 temperature sensor was made to be displayed on the LCD screen in Celsius degree.

For the accuracy test, an analog temperature sensor was used to output the current room temperature, and the temperature displayed on the LCD screen was compared to the output from the analog temperature sensor. It was found that the displayed temperature agreed with the analog temperature sensor output.

For the responsive test, a table lamp was placed close to the sensor to create a heating environment. The displayed temperature kept going up until the lamp was removed. After the lamp was removed, the displayed temperature started dropping to the room temperature.

From the tests mentioned, it could be said that the temperature sensor worked properly as desired.

2.2.3 User Identification Test

For the user identification test, multiple user profiles were entered to the system, and each of them had a unique RFID tag number. The LCD screen was made to display the user's name while the antenna senses the corresponding RFID tag.

As one or multiple RFID tags were passed through the antenna, the system was able to identify each different user and display the names corresponding to the specific RFID tag on the LCD screen.

2.2.4 Overall Function Test

For the overall function test, the system was tested as it was used in real life. Five user profiles were entered to the system, and each of them had his or her own RFID tag. Different lighting and temperature preferences were set for each user.

As different RFID tags were passed through the antenna, the LCD screen was able to display the user that entered the room correctly, and the lighting and temperature switches were able to turn on and off according to the users in the room and their unique preferences. The settings for different time zone also worked well.

III. CONCLUSION

3.1 Successes

Overall, the project was successful. The main components of the project were completed and functional. The project had several major components
and it can be considered a success in implementing each part and combining them together to make one working system. The RFID reader is fairly consistent in picking up tags. The temperature sensor constantly updates and is accurate to 1 deg Celsius. The LCD was a big success in that it is visually pleasing. It has several easy to use menus for users to use. Although there is only 1 antenna, the project included the ability to use 2 antennas for detection through the relay switching.

3.2 Uncertainties

One uncertainty is the reliability of the antenna. Although the reader can pick up a tag around 90%+ of the time, sometimes it does not. Other times it reads the tag too many times, thus causing the system to think the user is in and out. This program would most likely be solved with 2 antennas and doing some testing on how best to setup the system. As there was only 1 antenna available, this problem could not be addressed. Another issue is noise interference. It was hard to actually measure the noise on the signal. The oscilloscope cannot measure up to 900 MHz. It was also hard to determine where the noise interference was coming from.

3.3 Ethics

The goal of the project is to provide a convenient and hassle free way to turn on the basic necessities (lighting and heating/ac) when you enter a room. This can be very beneficial to elderly and handicapped people as it can save them several trips to the light switch and thermostat. However, one issue that seems to be overlooked these days in the era of new technologies that improve life is a possible side-effect of having technology do everything for us. America, especially, is fighting a battle with obesity. Granted, poor food diets are the main cause, but all these hands-free, automatic technologies have made us a "couch potato" society. Instead of doing normal sit-ups, a person can sit on the sofa and stick electronic pads, connected to a machine, on his/her stomach to build abs. Treadmills come with LCD televisions, magazine holders, personal fan, smart voice coach, etc. With all the benefits of technology, we seem to have forgotten that it still takes hard work. Like sci-fi movies, will our bodies become obsolete?

Another ethical issue is about the safety of the RFID tags. A recent report by AP claims that RFID tags implanted into mice led to the development of tumors in those animals. The FDA has approved RFID as safe but this new research could change that. It has huge economical implications on the RFID industry. Companies such as VeriChip Corp plan to use RFID tags for medical monitoring, which can be a huge market.

3.4 Future Improvements

For further improvements, the system should be developed to be able to handle more than 5 users. Depending on the room type, up to 100 users might be needed. Another issue is there was not enough time to try out the anti-collision feature which is supposed to help the reader detect multiple tags. This should improve the reliability of the reader when the number of tags approaches 5 or more.

The system itself is on a protoboard, so moving it to an enclosed case with a bigger LCD screen and input pad would make it much more marketable. The antennas would have to be worked on, perhaps making them smaller so they will be less noticeable when placed in a room. A security feature could be added to the system to prevent tampering. Also, all the user information and clock have to be setup when the system starts up. Adding a static memory would allow the system to store that information and save the hassle of repeatedly entering information.

IV. REFERENCES

Figure C.7: Test on Tag Placed In a Wallet

Figure C.8: Test on Different Numbers of Tags