Abstract- In the recent years, the Home Automation systems have seen rapid changes due to introduction of various wireless technologies. The explosion in the field of wireless technologies has seen the emergence of many standards, especially in the industrial, scientific and medical radio band. ZigBee is an IEEE 802.15.4 standard for data communications with business and consumer devices. ZigBee is targeted at applications that require low data rate, long battery life, and secure networking. ZigBee has a defined rate of 250kbit/s, best suited for periodic or random data; or a single signal transmission from a sensor or an input device. The SMART HOME SYSTEM will be implemented in existing home environments, without any changes in the infrastructure. The automation focuses on recognition of voice commands and uses low-power ZigBee wireless communication modules along with a microcontroller. This system is most suitable for the elderly and the disabled persons especially those who live alone and since it involves recognition of voice; it is secure. The automation system is intended to control all lights and electrical appliances inside a house or an office using voice commands.

Keywords- Easy VR 2.0, Home Automation, Voice Controlled, ZigBee

I. INTRODUCTION

The demography of the world population shows a trend that the elderly population worldwide is increasing rapidly as a result of the increase of the average life expectancy of people [1]. Caring for and supporting this growing population is a concern for governments and nations around the globe [2]. Home automation is one of the major growing industries that can change the way people live. Some of these home automation systems target those seeking luxury and sophisticated home automation platforms; others target those with special needs like the elderly and the disabled. The aim of the reported Voice Controlled Smart Home System (VCSHS) is to provide those with special needs with a system that can respond to voice commands and control the on/off status of electrical devices, such as lamps, fans, television etc. in the house. The system should be reasonably cheap, easy to configure, and easy to run. How to make people’s life more convenient, more comfortable and safer and how to save more energy will be the series of questions discussed in this paper.

Figure 1: uControl Home Security, Monitoring and Automation (SMA) [3]

There have been several commercial and research projects on smart homes and voice recognition systems. Figure 1 shows an integrated platform for home security, monitoring and automation (SMA) from uControl [3]. The system is a 7-inch touch screen that can wirelessly be connected to security alarms and other home appliances. The home automation through this system requires holding and interacting with a large panel which constraints the physical movements of the user [4].

Another popular commercially available system for home automation is from Home Automated Living (HAL) [5]. HAL software taps the power of an existing PC to control the home. It provides speech command interface. A big advantage of this system is it can send commands all over the house using the existing highway of electrical wires inside the walls of the house. No new wires means HAL is easy and inexpensive to install. However, most of these products sold in the market are heavily priced and often require significant home make over.

The rest of the paper is organised as follows: Section II provides a system overview. The hardware design is detailed in Section III while the software design is detailed in Section IV. The experimental results are discussed in Section V. The paper concludes by looking at the future research and development work required to make the system more versatile.

II. SYSTEM OVERVIEW

The Voice Controlled Smart Home System (VCSHS) is an integrated system to facilitate elderly and disabled people with an easy-to-use home automation
system that can be fully operated based on speech commands. The functional blocks of the overall system are shown in Figure 2.

![Functional Block Diagram of Voice Controlled Smart Home System (VCSHS)](image)

The system consists of two modules:
- Handheld Microphone Module with a ZigBee transceiver and a Voice Recognition unit
- Appliance Control Modules with relay controlling circuits

There are two microcontrollers in this project. Wireless communication is set up by two ZigBee chips. One of them is connected to the first ATmega328 working as the transmitter to transmit the signal and the other one is connected to the second ATmega328 working as the receiver.

ATmega328 is chosen at the transmitter part because the Easy VR 2.0 is most compatible with it and it has an inbuilt microphone which can receive and store voice signals from people.

Figure 3 illustrates the sequence of activities in the VCSHS. The system is activated when a user utters the trigger word or the password. Further, the user is required to say his/her name in order to have himself/herself recognized as a valid user of the system. When a valid user says a particular voice instruction, the microphone of the Easy VR 2.0 gets it first and then the ATmega328 at the transmitter receives it. By program controlling, the ATmega328 will send a particular character to the transmitter ZigBee. When the ZigBee is enabled, it will send the corresponding character to the receiver ZigBee. The characters sent differ as per the voice instructions of the user. When the wireless communication is established successfully, it will send instructions for ATmega328. Consequently, the appliances can be turned ON or OFF or controlled like increasing or decreasing the speed depending on the control characters received.

### III. HARDWARE DESIGN

In this section, the hardware descriptions of the two modules that constitute the VCSHS are discussed.

A. Handheld Microphone Module with a ZigBee transceiver and a Voice Recognition unit

The components of the microphone module are as shown in Figure 4.

![Voice Controlled Smart Home System Handheld Microphone Module](image)

The human voice is captured through the microphone. It is matched with the voice previously recorded in the Easy VR 2.0. If it matches the corresponding character is sent through ZigBee. Here, Easy VR 2.0 is the voice recognition unit.

The Easy VR 2.0 voice recognition module along with ATmega328 constitutes the Speech Recognition System. It is an easy to use programmable speech recognition circuit. Programmable, in the sense that you can train the words (or vocal utterances) you want the circuit to recognize. It allows you to experiment with many facets of speech recognition technology.

B. Appliance Control Module

Once the speech commands are recognised, control characters are sent to the specified appliance address through ZigBee communication protocol.
appliance that has to be controlled has a relay controlling circuit.
The components of appliance control module are shown in Figure 5.

![Figure 5: Appliance Control Module](image)

Control characters corresponding to the recognized commands are then sent serially from the central controller module to the appliance control modules that are connected to the home appliances.

**IV. SOFTWARE DESIGN**

Software Design includes Voice Recognition Application and ZigBee RF communication.

A. Voice Recognition Application

The voice commands are trained and on the Easy VR 2.0 voice recognition unit using the software named “Easy VR Commander”. A snapshot of this software is shown in Figure 7. It gives an option of entering any custom voice command and then training the module to recognize the command typed. Also, that voice command can be tested for accurate recognition by saying it in the microphone and then the software indicates the command spoken on the screen. This software also has a feature of generating an Arduino-based code depending on the number of voice commands trained, which is compatible with “Energia”. Here, the software “Energia” is used to program the Arduino UNO development board, which contains the Atmega328 IC.

![Figure 6: Voice Recognition Unit](image)

Features:

a. Supports Voice Passwords
b. Can be used with any host with a UART interface (powered at 3.3V – 5V)
c. Simple and Robust serial protocol to access and program the module through the host board
d. Arduino Libraries provided
e. Connector for microphone input
f. 8 ohm speaker output
g. Headphone jack

B. ZigBee RF communication

ZigBee protocol is the communication protocol that is used in this system. ZigBee offers 250 kbps as maximum baud rate, however, 9600 bps was used for sending and receiving characters. ZigBee is a low-power wireless communication technology designed for monitoring and control of devices. Based on the 802.15.4 standard, ZigBee technology provides a robust and a reliable solution in noisy radio frequency (RF) environments.

ZigBee features include energy detection, clear channel assessment and channel agility help devices pick the best possible channel and avoid other wireless networks such as Wi-Fi® while message acknowledgement ensures that the data is delivered to its destination. Multiple levels of security ensure that the network and data remain intact and secure.

One of ZigBee's key features is its ability to cover large areas with routers. This feature helps differentiate ZigBee from other technologies. Mesh networking extends the range of the network through routing, while self-healing increases the reliability of the network by re-routing a message in case of a node failure.

ZigBee technology supports two feature sets (ZigBee Feature Set and ZigBee Pro Feature Set), which focus on specific markets.
The "ZigBee" feature set targets home and light commercial environments that are designed for simpler plug and forget networks.

The "ZigBee Pro" feature set includes features and enhancements in the ZigBee feature set and adds elements designed for larger, more complex networks, such as centralized data collection, network scalability, automated address management and group addressing.

Freescale provides all the building blocks needed for both ZigBee and ZigBee Pro feature sets including hardware, software, tools and referenced designs.

The development hardware and reference designs provide developers with the tools needed to easily and quickly implement these building blocks. One solution, one provider—built, tested, compatible and ready for integration.

ZigBee Key Features:

a. Low Power
b. Robust
c. Mesh Networking
d. Interoperability

The software “X-CTU” was used to configure the ZigBee transceivers for RF communication.

The pan-id of both the ZigBee modules was set to the same value so that the character sent by the transmitter ZigBee can be read only by the receiver ZigBee, which has the same pan-id as the transmitter one.

Thus, interception of data is avoided and data transmission is secure. A ZigBee module can be configured to operate in two different configurations – as a co-ordinator or as a router. Here, any one ZigBee module is configured as a co-ordinator and the other as a router.

V. EXPERIMENTAL RESULTS

The prototype of the system is implemented and tested. Four different voice commands, “LIGHTS ON”, “LIGHTS OFF”, “FAN ON” & “FAN OFF” are trained for two male and two female users.

Also, for the purpose of speaker authentication, they are made to speak their names in their own voice.

A specific character is sent only on recognition of a valid command, else no character is sent. The experimental results are shown in the figures below.
Voices Controlled Smart Home System

Figures 8 and 9 depict the Serial Monitor Output at the transmitter side for a valid male user and a valid female user. From the experimental results, it can be concluded that the voice recognition unit recognizes the voice command being spoken accurately 75-80% of the times, in indoor conditions, but in the presence of noise, the efficiency of the voice recognition unit goes down considerably.

The ZigBee RF communication is reliable in indoor conditions, but when obstacles are introduced, data transmission is affected.

CONCLUSIONS AND FUTURE WORK

A home automation system based on voice recognition is built and implemented. The system is targeted at elderly and disabled people. The prototype developed can control electrical devices in a home or an office. The system implements voice recognition using Easy VR 2.0 shield. Wireless communication is established using ZigBee RF modules because of their efficiency and low power consumption. The preliminary test results are promising.

Future work will entail:
- Adding confirmation commands to the voice recognition system
- Integrating variable control functions to improve the system versatility such as providing control commands other than ON/OFF commands. For example: “Increase Temperature”, “Dim Lights” etc.
- Integration of GSM or mobile server to operate from a distance
- Design and integration of an online home control panel to display the status of the devices connected to the system

REFERENCES


