

Voice Controlled Home Automation System for the Elderly or Disabled People

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ABSTRACT

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. Typical wireless home automation system allows one to control house hold appliances from a centralized control unit which is wireless. These appliances usually have to be specially designed to be compatible with each other and with the control unit for most commercially available home automation systems. The developed system can be integrated as a single portable unit and allows one to wirelessly control lights, fans, air conditioners, television sets, security cameras, electronic doors, computer systems, audio/visual equipment's etc. and turn ON or OFF any appliance that is plugged into a wall outlet, get the status of different sensors and take decision accordingly. The system is portable and constructed in a way that is easy to install, configure, run, and maintain. The perfect user interface still does not exist at present and to build a good interface requires knowledge of both sociology and technology fields. According to major companies that are involved in speech recognition researches, voice will be the primary interface between humans and machines in the near future. The problem lies with the situation of the elderly or disabled people, who cannot usually help themselves to move around, and might require external assistance. People who live alone might also need a helping hand at home. Therefore a voice controlled home automation system is designed, so that the users can perform certain tasks by just the use of their voices, moreover, the system is designed to have a hand-held device(remote) so that the user can easily speak their commands, otherwise they would have to walk over to the microphone to speak. Having a remote will make the system more user-friendly and portable.

KEYWORDS: Home Automation, Voice Control, Smart Home, Ubiquitous Computing, Wireless Communication.

INTRODUCTION

Smart Homes systems are somewhat different from ordinary homes, where the different smart devices in the presence of communications network being installed that allows the devices to communicate with each other. Integrated communication systems provide the facility for monitoring and managing the performance of the home, and offer the choice support to the occupants for available facilities. The varieties of systems are installed in today's modern home such as central air conditioned and heating, fire and security alarms, and different other devices, such as home theater, televisions, lights etc. These systems and devices usually exist in total isolation from each other. Smart home provides the facility of passing information and commands among different installed devices and systems. Such facility and control not only provide better control locally and remotely but also supports special needs, particularly services that support the elderly. Smart home technology also greatly improves the usability and functionality of any home. It also allows to potentially reducing power consumption by preventing occurrences such as lighting and air conditioning being left on longer than necessary. A smart Home Automation system allows saving money and the environment.

The remainder of this paper is organized as follows: In next section, the related work done by other researcher on voice controlled systems is provided. In Section 3, proposed design is presented. The implementation details are discussed in Section 4. Results of system testing are presented in Section 5 followed by conclusions in the last section.

1. LITERATURE REVIEW

A There are some project that have been completed which regard to the application of the voice in the controlling method. In [1], an intelligent home navigation system (IHNS) is proposed to facilitate the elderly and the physically challenged persons. It proposes an idea of an automated voice based home navigation system. The system comprises over a wheelchair, navigation module and voice module. It uses a speech recognition module SR-07 and a line follower module for navigation. The system has predefined voice commands relating to different rooms, and predefined routes relating to those rooms for the navigation. There is also a collision avoidance system installed in the project.

In [2], the intelligent access control system is developed that is based on SPCE061A voice recognition chip. The supporting software comprises of the voice training module, the voice recognition module, the voice data processing module and the voice-playing module. The system completes the functions of collecting the voice data, distilling character, special voice recognition and voice playing in terms of initializing the system and the identification training. The central

processor of this system is the SPCE061A single chip. The talker confirmation that is relevant to text is realized on the chip, and then homologous order and operation are carried out.

The proposed system comprises over a voice controlled wheel chair. The system is built using low cost speech recognition board and a microcontroller. The speech recognition board utilizing HM2007 speech recognition chip. It uses an idea of paired-word for issuing a command to the system, so that if words similar to the voice commands are spoken within the vicinity of the voice recognition kit, they are not accidentally detected. The system is speaker dependent and also an isolated speech system, to avoid further accidental voice detections [3].

The system presented in [4] is the voice controlled smart house. It works on the predefined set of voice commands for the defined areas in a house. The new commands can be added in as required. FIS, a pattern processing technology, is used that allows processing of complex patterns as experienced in speech and vision.

The project Voice Controlled House Automation System (VCHAS) uses an RF module and AVR Microcontroller. The previous systems have not been made handheld, and so do not require an RF module, since they do not employ a remote. In the developed project, device is made more portable, low cost and easy to use, by making it a hand-held device.

Table 1. Comparison chart for voice controlled systems available in the market [5]

	Automated Voice based Home Navigation System	Intelligent Access Control System	Voice Activated Wheelchair	Voice Controlled Smart House
Navigation Module	✓	✗	✗	✗
Voice Module	✓	✓	✓	✓
Collision Avoidance	✓	✗	✗	✗
Data Processing	✗	✓	✗	✗
Voice Playing	✗	✓	✗	✗
Speaker Dependent system	✓	✓	✓	✗
Finite inductive Sequence (FIS) system	✗	✗	✗	✓

2. Proposed Design

The system is divided into three parts: Transmission block, controlling block and receiving block.

2.1. Basic Design Blocks

The system is divided into three basic design blocks namely;

- i) Transmission block
- ii) Controlling block
- iii) Receiving block

An entire scenario of design will be presented as follows, by the help of these two figures. The first figure is representing the transmission block and the second representing the Control and Receiving block. Together they represent the flow of the entire system, and explain the way in which it will work.

2.1.1. Transmitting block

2.1.1.1. Voice input block

The Voice input block takes the voice of the speaker as an input signal, as the name implies. This block comprises of an input device, which might be a sensor, to detect voice as an analog input to the system. The analog input signal is then passed onto the block responsible for receiving and processing the input signal.

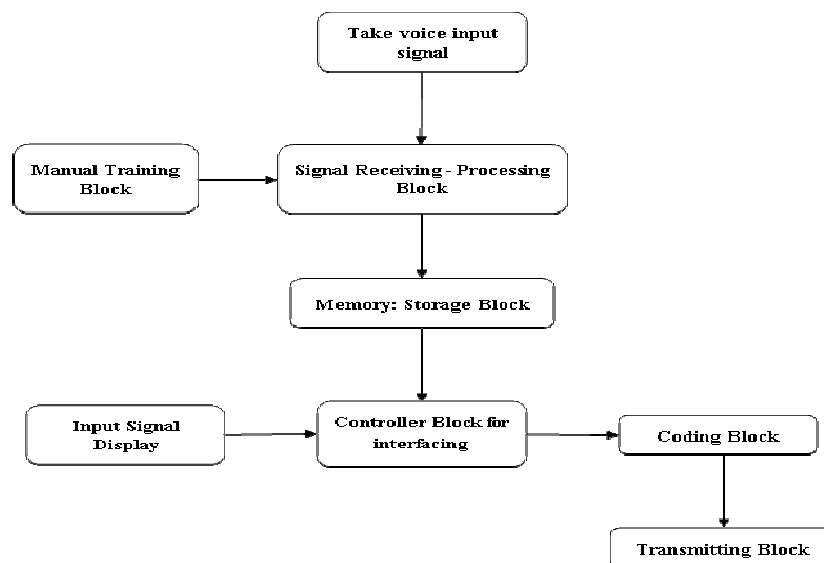


Fig. 1. Transmission block

2.1.1.2. Signal receiving and processing block

The signal receiving and processing block is responsible for receiving the analog voice input signal, and converting it into a digital signal so that it is compatible with the rest of the system. This block is also responsible for storing the commands, which will be later term as the preset commands. This block is trained according to human voice vocabulary, and it matches and identifies voice commands, relating to the function it is expected to perform.

2.1.1.3. Manual training block

The manual training block is used to train the signal processing block, for the commands needed to be set, so that later those commands can be used to match input signals and initiate the required tasks of appliance control.

2.1.1.4. Storage block

When the signal processing block is trained, through the manual training block, space to store input commands is required. Space is needed to retain predefined commands as addresses in the memory, and later match the spoken commands with the predefined commands to perform a function. In this block, first predefined commands are saved and later they are used for matching with the voice input to perform a defined task.

2.1.1.5. Controller block

The controller block is responsible for interfacing the rest of the circuitry with the upper part of the circuit; otherwise there is no other medium of creating a connection of the input and storage blocks with the display section, and the coding block.

2.1.1.6. Display block

The display block is included, since it was needed to make the system more users friendly and easily accessible to all. The display block displays the command that have spoken, so that they can also be visualized, and also know the function that is going to be performed. In case of errors, it also notifies about the error. It is a medium of sense created to help the users.

2.1.1.7. Coding block

There is a need to code signal so that it become possible to interface the upper part of circuit with the transmitting block.

2.1.1.8. Transmitting block

It is to send signal from one point to the point of reception using suitable transmission technology.

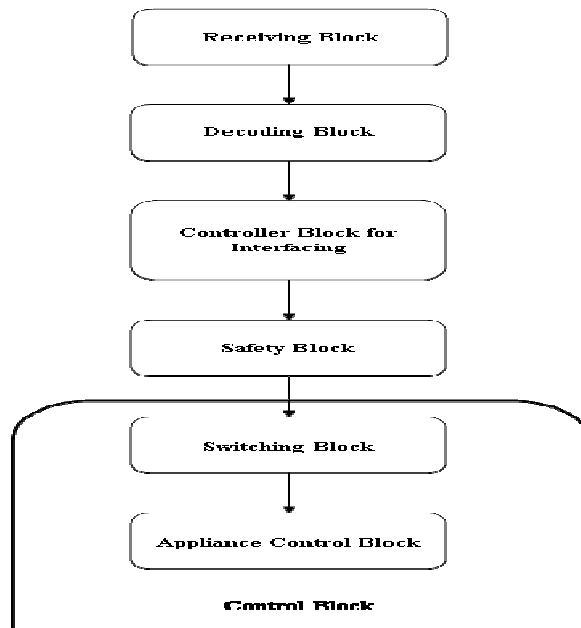


Fig. 2. Receiving and controlling block

2.1.2. Controlling block

2.1.2.1. Receiving block

This block will be used to receive signal serially from one point to the other.

2.1.2.2. Decoding block

A decoder is used at receiver, almost in a manner similar to the coding block, to interface receiver with the rest of the circuit.

2.1.2.3. Controller block

The controller block is responsible for interfacing the rest of the circuitry with the lower part of the circuit; otherwise there is no other medium of creating a connection of the received input with the safety section, and the switching block. The controlling block handles the processes to be able to select which appliance is supposed to be operated.

2.1.2.4. Safety block

It is necessary to create a safety circuit, so that the system is protected against damage, in case of any back EMF or high voltage etc. this block is responsible for a no-physical-connection route towards the rest of the circuit, preventing damage due to physical connections.

2.1.3. Receiving block

The entire receiving block is responsible for switching and operating the appliances or devices.

2.1.3.1. Switching block

The switching block is used so that it can be decided whether the device is to be switched ON or OFF, according to the signal received by the controlling circuit.

2.1.3.2. Appliance block

This block is the end of the system, and this is where the home appliances will operate.

3. Implementation Details

VCHAS is a smart home system. This burgeoning industry has spawned a choice selection of products from several respected manufacturers. Home automation systems usually work on wireless technology, but very few are actually voice controlled. The proposed system is an innovation to this technology where the VCHAS is introduced to be more compatible and convenient by bringing a hand-held device to the consumers. VCHAS uses a transducer, keyboard, Integrated circuit for speech recognition, RF module, and AVR microcontroller primarily. Additional equipment such as the LCD is commonly added to expand the home automation system's capabilities and make it more users friendly.

3.1. System Architecture

The system depends upon a transmitting section and a receiving section, that is apparent in system architecture diagram (refer to figure 3).

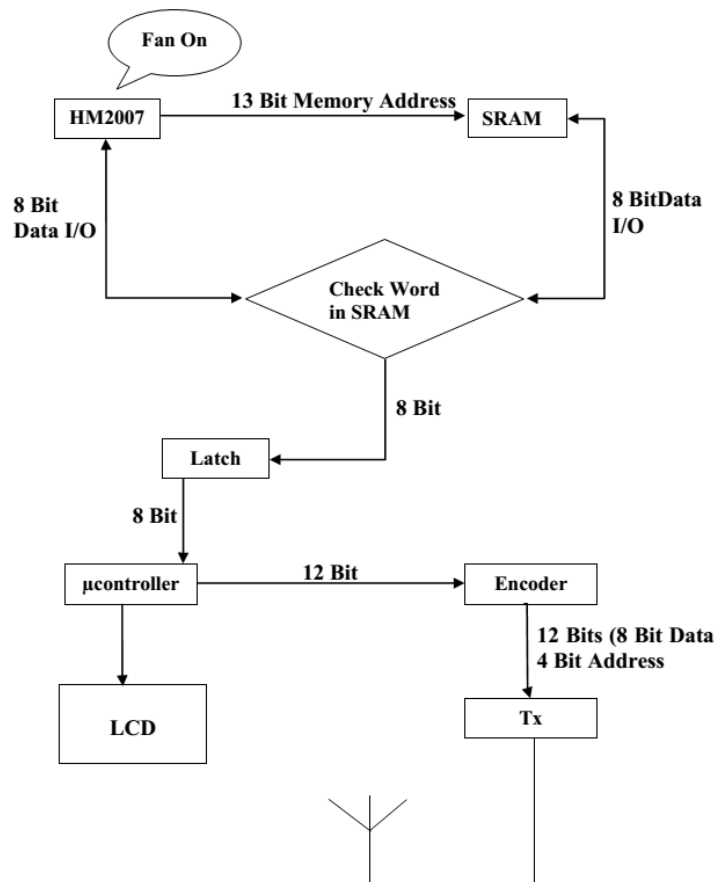


Fig. 3. Architecture of transmitting circuit

The system is based upon the use of voice as a physical parameter, which is later conceived as a command by the VCHAS. The question is about interfacing voice commands with the rest of the system. To move ahead with the process, a transducer is used, for the purpose of converting physical parameter of voice into an electrical signal. HM2007 (Speech Recognition Chip) [6] is available with a pin, to which a microphone can be directly connected, for the purpose of speaking the command verbally into the circuit.

3.2. Voice based controlling requirements

3.2.1. Speech Recognition

Speech recognition is becoming the method of choice for controlling appliances, toys, tools, computers and robotics. The voice controlled appliances like computer, TV, lighting system, security system, etc. become easier to use, while increasing the efficiency and effectiveness of working with that device.

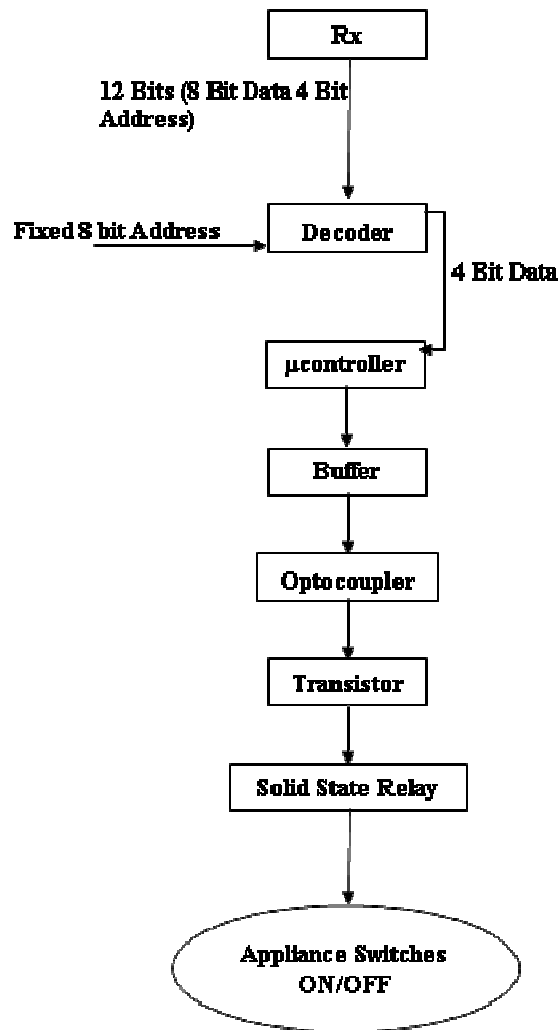


Fig. 4. Architecture of receiving circuit

Different Speech recognition integrated circuit are available in the market. The HM2007 speech recognition integrated circuit is one of them that provides the options of recognizing either forty .96 second words or twenty 1.92 second words. It allows either the .96 second word length (40 word vocabulary) or the 1.92 second word length (20 word vocabulary). The HM2007 stores the "trained" word patterns used for recognition in external memory. For memory, the circuit uses an on board 8K x 8 static RAM supported by coin battery. The main board has a coin battery holder that provides backup power to the static ram when the main circuit is turned off. This keeps all the trained words safely stored in memory (SRAM) so the circuit does not have to be retrained every time it is turned on [7].

3.2.2. Speaker Dependency

Speech recognition is classified into two categories, speaker dependent and speaker independent.

Speaker independent is a system trained to respond to a word regardless of who speaks. Therefore the system must respond to a large variety of speech patterns, inflections and enunciation's of the target word. The command word count is usually lower than the speaker dependent however high accuracy can still be maintained within processing limits. Industrial requirements more often need speaker independent voice systems.

Speaker dependent systems are trained by the individual who will be using the system. These systems are capable of achieving a high command count and better than 95% accuracy for word recognition. The drawback to this approach is the system only responds accurately only to the individual who trained the system. This is the most common approach employed in software for personal computers. VCHAS employs the speaker dependent system, since it is one of the major characteristics of the IC HM2007 chip used.

3.2.3. Recognition Style

One of the constraints of speech recognition systems is the style of speech they can recognize. There are three different styles of speech that are isolated, connected and continuous [7].

Isolated speech recognition systems – It can only handle words that are spoken separately. This is the most common speech recognition systems. The user must pause between each word and command spoken. Connected – It is a half-way point between isolated word and continuous speech recognition. It allows users to speak multiple words.

Continuous – It is the natural conversational speech people are accustomed to in everyday life. It is extremely difficult for a recognizer to shift through the text as the words tend to merge together.

Isolated speech recognition system is another feature, of IC HM2007, and a characteristic of the system.

3.3. Training voice recognition module

Before utilization of the system, it is required that the user should train the system according to their choice of words, to provide better accessibility to the user. The circuit can be fed with the commands desired by the user, and for that, HM2007 is interfaced with a microphone, keypad and 7-segment display, thus increasing user compatibility.

When the system is switched ON to be trained, the 7-segment display shows "00" and the LED is turned ON. Suppose there is a need to record a command at number "24", so the digits "24" on the keypad are pressed, and the LED turns OFF.

Now to train "#", is pressed, thus switching the LED ON. When the LED turns ON, it is time to speak command into the Microphone verbally, within 1.92 seconds (20 words). When the LED starts blinking, it means the word is being stored into the SRAM and VCHAS is successfully trained for the particular voice command, to be used again and again in the future.

CLEAR ALL pattern is also available. If the key is pressed with number "99" and later "CLEAR" is pressed, all previous storage is erased [6].

3.4. The Voice input

At the time of storing voice input as commands to the system, a 13 bit address is passed onto the memory, SRAM where the addresses are defined, containing information about what commands are stored where in the memory. Later, when the commands are spoken into the microphone, an 8 bit of data is sent to the SRAM from the HM2007 and the SRAM matches the command for the address where it is stored. If the input data of the command does not match the stored commands, then an error signal is generated, otherwise the command is passed onto the latch.

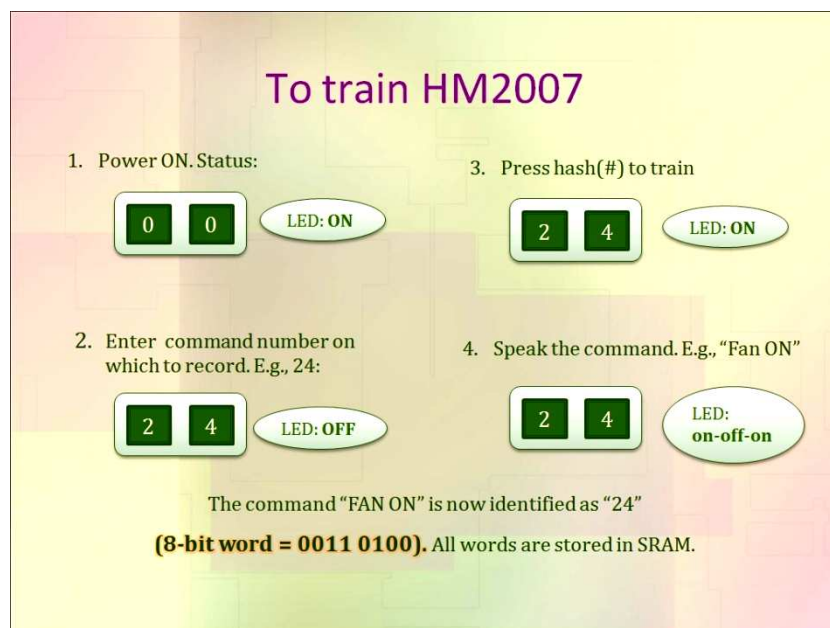


Fig. 5. Training the voice recognition module

3.5. Microcontroller interfacing with LCD and Encoder

After the data is matched, the 8 bit of data is stored onto the latch, to be sent to the microcontroller. The Microcontroller interfaces a 16 x 2 LCD and an encoder to the circuit [8]. The LCD displays the command that have been spoken, as the microcontroller was previously programmed to display certain commands for certain numbers. 12 bits of data are sent from the microcontroller to the encoder. Encoder converts received parallel 12 bits of data (of which 8 bits are of address and 4 bits are of data) into serial and sends to the transmitter [9].

3.6. RF module

The RF module consists of a transmitter and a receiver. It will be operating within a range of 433MHz. The transmitter will transmit 12 bits of data serially, bit by bit, to the receiver. The receiver will receive the data one bit at a time, and serially.

3.7. Microcontroller Interfacing with Decoder and Buffer

At receiver, the decoder decodes the serial addresses and data received into parallel data and sends them to output data pins. The received data is compared with the local addresses three times. The data is decoded only in case no error or unmatched codes are found. High signal is generated at VT pin in case of a valid transmission. The 4 bits of data and 8 bits of address are now sent to the microcontroller. From the microcontroller the data is sent to the buffer. The buffer acts as a driving for current in the circuit[8][9].

3.8. Safety Circuit

The current is now passed on from the buffer to the Optocoupler. Optocoupler is used, so that there is no physical connection between the receiving part and the controlling part, in case there is ever a reverse current flow or leakage, and otherwise the circuit will be damaged. From the Optocoupler the current is passed onto the transistor.

3.9. Solid State Relay and Devices

The solid state relay used as a switch to which devices to be operated are connected. When the relay is switched on, the devices are also turned on.

3.10. Design Implementation of VCHAS

While implementing the design proposed for the voice controlled home automation system, three important sections of division have been brought under consideration, that were assumed for the sake of ease and understanding, which is nonetheless virtual.

The three important divisions are:

- The transmitter: Hand held device
- The receiver: Pluggable sockets
- The load operation: Appliance control

3.10.1. Hand Held Device

The voice controlled home automation system, has a unique design, where it uses a handheld transmitter section. The device is handheld and more accessible to the user. As the user may be a disabled person, or a patient, he can easily use the remote and speak his desired command. The handheld technique is potentially a new idea, and has not been previously implemented; hence it differentiates this implementation from the previous innovations of the system.

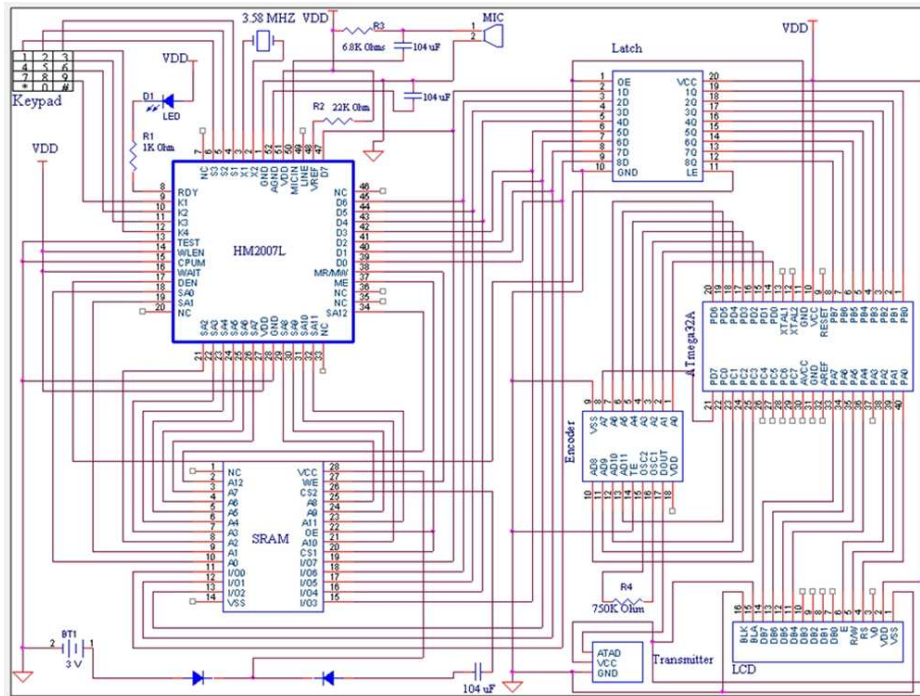


Fig. 6. Schematic of hand held device

3.10.2. Receiver and Control circuits

The receiving section of the circuit, comprises of a pluggable socket, at the backhand of which, operates receiving section. Whatever load or domestic application devices are plugged into the socket, will then be controlled by the voice controlled home automation system, and a command pre-saved into the system will be used to control the device.

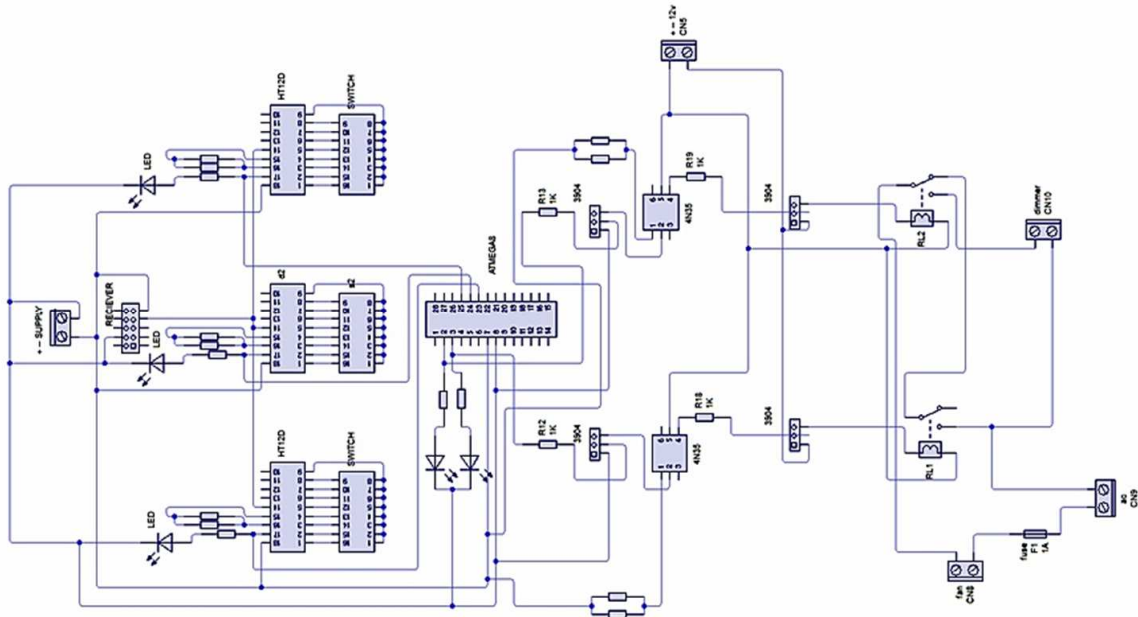


Fig. 7. Schematic of Fan receiving circuit

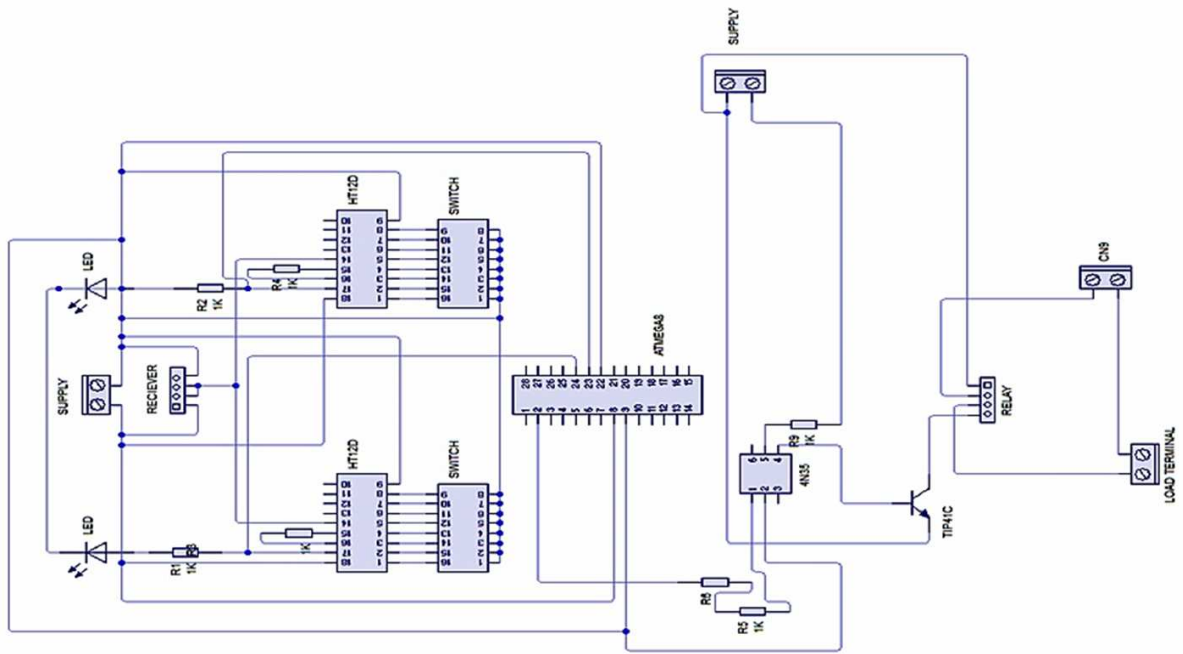


Fig. 8. Schematic of Bulb Receiving Circuit

3.10.3. Appliance control

The aim is to control two basic home appliances at this stage, namely the light bulb and fan.

3.10.3.1 Light bulb

The light bulb has two states to be controlled, namely

- The ON state
- The OFF state

3.10.3.2. Fan

The fan has three states to be controlled, namely

- The ON state
- The OFF state
- The MEDIUM state
- The HIGH state

4. RESULTS AND DISCUSSIONS

4.1. Methods of Testing

The voice controlled home automation system has been tested in different methods. It has been tested in both noisy and quite environments, and is found to give better results in quite environments, where it picks less or no noise signals.

The hand-held device is also tested with multiple speakers, speaking onto the device at the same time and separately as well. The device responds to only the voice, which is used to train the IC HM2007, and not to any other voices. The system of VCHAS has also been tested with the range of the room it covers.

Another method of testing was, to train IC-HM2007, with different commands to operate the same kinds of devices located in different rooms, example ‘Fan1-on’ for fan of room 1 and ‘Fan2-on’ for the fan of room 2, without the commands being mixed or confused by the device.

4.2. Limitations

While working on the system, several limitations are highlighted, such as the system produces error in response to environmental noise, and requires absolute silence and solitude to work properly, otherwise it can pick noise signals, and produce error in response to it.

Another thing noticed about the system development is, that since IC-HM2007, sends out a unique address each time a command is spoken, it must have a separate decoder to match addresses with. This way, there is the requirement to use many different decoders for each approaching address, which makes the circuit design slightly complicated.

The receiver and transmitter circuits will not work at 7V or below, so batteries used should be of good quality and be kept under check.

4.3. Results

Controlling of two devices of household appliances are successfully achieved, the fan and light bulb. The fan can be voice controlled for three levels of speed, full speed, and medium speed and off state. The bulb can be voice operated upon two levels of ON and OFF, and the same system can also be used to operating heavier loads in household, example, an air conditioner (refer to Table 2).

Table 2. Results

TESTING METHODS	TESTING FACTORS	DEVICE RESPONSE	OUTPUT ACCURACY
AMPLITUDE OF VOICE	Normal conversation 60dB	Device responds 3 out of 5 times	60%
	Whisper 35dB	Device responds 1 out of 5 times	20%
NUMBER OF WORDS	Minimum 2 words	Device responds accurately 2 out of 2 times	100%
	Maximum 5 words	Device responds accurately 2 out of 5 times	40%
DISTANCE FROM MICROPHONE	Lesser distance 5 Inches	Accurate response 4 out of 5 times	80%
	Greater Distance 2 Feet	Accurate response 2 out of 5 times	40%
ENVIRONMENTS	Quite	Accurate response 4 out of 5 times	80%
	Noise	Accurate response 1 out of 5 times	20%
MULTIPLE SPEAKERS	Multiple speakers	Device responds accurately 1 out of 5 times	20%
	Individual speaker	Device responds accurately 4 out of 5 times	80%
ROOM SIZE	Small room	Accurate response 3 out of 5 times	60%
	Large room	Accurate response 1 out of 5 times	20%

5. Conclusions

The purpose is to control some of the major household devices by voice. It is not only aimed at providing a healthy and comfortable lifestyle to the users, but also at aiding the sick or handicapped and people living alone, so that they can easily handle all their tasks at a convenience. Making the design sleeker and easier to handle, with a method to control more appliances at a time is the future requirement.

We have so far achieved in controlling the same appliance, example, a light bulb, at the same time in two different rooms, and we have been able to control larger loads, for example, an air conditioner. The design of the voice controlled home automation system, is both portable and ready to be installed in your main household circuit. We have introduced portability in the entire system, both the voice controlling remote, and the application end.

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