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Design and Construction of Speech Controlled Door

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Home security is extremely important, and several methods of security have been improved, such as the usage of alarms, monitoring systems, and the interplay of electronic hardware, software, and other factors. Keys can be misplaced and found by others, putting the guarded structure at risk; keys can also be fabricated or stolen. This project entails creating a voice message-based door access system that can both open the door and identify intruders, trespassers, criminals, or any other type of illegal behaviour. The speech-controlled door was meant to generate a voice message based on the input data and was developed around a microcontroller (ATmega328p). A speech recognition module is used to allow the owner or user entry to the door. To gain access to the door, the owner must first utter the specific speech or key word required to open it. A voice notification is then outputted through the associated speaker if the pronounced word does not match the speech recognized by the microcontroller. To signify that access is refused, a red-light

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emitting diode will flash. The microprocessor would activate a relay and current will flow through the latch, allowing the door to be unlocked, if the uttered speech matches. A speech recognition module is used to allow the owner or user entry to the door. To gain access to the door, the owner must first utter the specific speech or key word required to open it. A voice notification is then outputted through the associated speaker if the pronounced word does not match the speech recognized by the microcontroller. To signify that access is refused, a red light emitting diode will flash. The microprocessor will activate a relay and current will flow through the latch, allowing the door to be unlocked, if the uttered speech matches.

Keywords: Door; recognition module; microcontroller; biometric; android; latch; voice controlled.

1. INTRODUCTION

A door is a moving structure that uses a key to both block and enable entry to an entrance to or within an enclosed environment, such as a building or vehicle. Gates are outside structures that are similar to fences. Doors usually have an interior side that faces the inside of the space and an external side that faces the outside of the area. While the inside side of a door may match the outer side in some circumstances, in others, such as the case of a vehicle door, there are dramatic contrasts between the two sides. A door is often made up of a panel that swings on hinges or slides or spins within an area. People, animals, ventilation, and light are all admitted when the door is opened (Falohun et al, 2013). Many doors have locking devices that enable certain people in while keeping others out. There are many different types of mechanisms that can be used to control doors, including hinged, sliding, rotating, high-speed doors, automatics, and so on. Most hinged doors are hinged on one side only, allowing the door to pivot away from the doorway in one direction but not the other. The rotating axis is usually vertical. This necessitates a mechanism with the axis of rotation on the opposite side of the door opening. Unauthorized employees entering the residence via doors opened with a master, forged, or stolen key has increased dramatically; this can be mitigated by implementing a voice-controlled door [1].

A voice-controlled door is one that is operated by a speech recognition module (VR3) and requires a speech before any employee may enter the closed room or building. The goal of this project is to sound an alarm that alerts the owner or security professionals to the presence of an intruder. To avoid system vulnerability, the speech can only be altered later by the owner of the protected building. This update can be made using an Android application that has been created to work with the system [2].

A key is meant to open and close doors mechanically. Keys can be misplaced and discovered by other workers, putting the secure premises at risk. Keys can be stolen or forged. Due to unanticipated circumstances, people sometimes fail to lock the door. Doors do not have the ability to sound alarms or alert the owners that an intruder is using them. Humans nowadays rely heavily on modern technologies to make their lives easier. This project, on the other hand, will offer the option of replacing a door key with a secure door locking system. This will be the most effective answer to all of the aforementioned issues. The goal is to develop a speech-controlled door by building a door system that responds to a speech template and then training the speech module to synchronize with the door system [3].

As a security system, the digital coded lock system restricts entrance to a building/room to only those classified individuals who have the access code, guaranteeing that unlawful access is prevented. The microcontroller in the voice-controlled door lock system would be designed to activate an output when the correct speech is pronounced. This speech is a single key word that the user can change and is remembered even when the power is turned off. A buzzer would be added to offer input feedback, with the amount of beeps indicating whether or not the input was submitted correctly. This system could be used to automate the opening of the door, for example, preventing unauthorized entry, by employing this circuit to control the door [4].

2. THEORECTICAL BACKGROUND

Humans have been endowed with creative and curious brains, allowing them to labor and invent for a higher quality of life. They never stop looking for and learning new things to deliver more intelligent and secure systems, tools, and methods for providing outstanding services to the public. They create inventions that make

people's life easier, such as making lock systems simpler and more safe. Numerous studies and researches have been carried out in order to produce an advanced and secure door lock system [5].

2.1 Gsm Based System

GSM is used for communication in several door lock security systems. The objective of a work is grown via the use of circuits such as a GSM module that is activated by a controller for sending SMS to the proprietor in the event of an emergency and for contacting corresponding security services in the event of a break in. The system requires a variety of sensors to detect impediments. It receives data from the sensors before making a decision. Sends SMS to a certain number with the help of the GSM module. A recently developed model for door security that can be operated remotely using a GSM hand set as the transmitter and another GSM phone set with DTMF (Dual-tone multi-frequency signaling) associated with the motor attached to the door using a DTMF decoder, a stepper motor, and a microcontroller unit. People nowadays want to feel safe even while they are away from home, hence the work presented by [6].

When the owner is not at home, the protection of his home and valuables is a major concern for everyone. Two frameworks based on GSM technology have been developed. The detection of gate-crashes is done by using a web camera to capture an image. When people are absent from their residences, the system sends a text message to the crisis number. A revolutionary administrator-based system allows users to log in quickly and easily to view and listen to recorded messages, as well as automatically lock the door utilizing mobile communication technology.

2.2 Smart Card Based System

A model entryway security framework is designed to allow an authorized user to gain access to a secure (keyless) entryway where a valid smart RFID card is required to ensure the door's pass. The microcontroller is in charge of all control functions [7].

2.3 Biometric Based System

The next phase in fingerprint recognition is palmtop recognition. It is based on the concept of a palmtop. The system first creates a picture of the palmtop, after which it partitions the image and performs the operation. Finally, be sure you're dealing with the right person. As a result, it lowers the risk of inaccuracy in other human recognition methods and highlights the issues with fingerprint recognition. In bank lockers, the biometric approach is extremely handy. Apart from fingerprint recognition, the vein detector and iris scanner provide the best and most accurate results, thus the microcontroller in the bank security system continuously checks the Vein Detector and Iris Scanner using keypad verified codes. During the night, the wireless motion detector will be operational, and if any modification in its output is detected, the controller will issue an alert sound (Oke et al., 2013).

2.4 Bluetooth Based Systems

A Bluetooth-based system is similar to savvy home innovations in that it makes advantage of the Bluetooth function found in smart gadgets. For proper usage, the Bluetooth framework proves to be more easy and productive. The Arduino platform is commonly used in such systems. Such a framework's hardware is a combination of an Android phone and a Bluetooth module. The Arduino microcontroller serves as a controller, and the solenoid can serve as the locking system's output [5]. Fig. 1 presented various kinds of door locks.

3. REVIEW OF RELATED WORKS

The most significant function of a door in terms of security is to control entry. It includes the door's configuration, durability, and composition, as well as the door's hinges and frame, as well as the latching and locking hardware's control and efficacy. When it comes to canceling access or reprogramming doors, electronic keyless door locks are said to be preferable. Push-button codes, proximity cards, or any combination of these approaches can be used as controllers. Access may include the keeping of logs or the creation of an audit trail by time and date stamping in and out transactions in the building. It is important to place locks in all doors or high – risk areas such computer labs according to the recommendation excerpted from Safety and Security by Department of Education, School Safety and Violence Prevention Office, 2002, pages 1 -5 (National Institute of Building Sciences, 2009).

Ajay et al. [8] developed a Microcontroller (MCUAT89S52) based Home Security system that uses diffused in line IR sensors and shock sensors to detect intruders, as well as a lock

system to automatically lock the intruder if it tries to enter the room. In addition, a GSM module is employed to send SMS alerting the intruder in the room.

Nikhil Agarwalet has proposed a micro-controller based automated Home Security System. Password-protected door locks use an LED-based resistive screen input panel that works by detecting differences in light intensity captured by the photo diode and reflected by the finger, which is emitted by surrounding red LEDs. IR Laser sensors are utilized to detect any impediment.

Khan et al. [9] demonstrated an Android-based control system for maintaining the security of the main entrance to the house as well as the car door lock. The system may also control all of the room's appliances. Bluetooth is used to connect a mobile device to a security system or a home automation system. The PIC microcontroller is used to create the hardware.

A section of smart home technology employing Bluetooth in a mobile device was introduced by Kamelia et al., [10]. The door locks automation system is proposed and prototyped utilizing a Bluetooth-based Android Smartphone. The hardware for the door-lock system consists of an Android smart phone acting as the task master, a Bluetooth module acting as the command agent, an Arduino microcontroller acting as the controller center/data processing center, and a solenoid acting as the door lock output.

Hasan et al. [11] discussed and examined the design and implementation of a GSM-based microcontroller-based home security system. The proposed security system's trustworthy operation is ensured by two microcontrollers and other peripheral devices such as a Light Emitting Diode (LED), Liquid Crystal Display (LCD), Buzzer, and Global System for Mobile Communication (GSM) Module.

“Android Based Smart Door Locking System with Multiuser and Multilevel Functionalities,” developed by another company, is another product [12]. When you compare products, you can see their strengths and weaknesses. The Arduino board, Android phone, Bluetooth Module HC-05, and Relay Switch are all used in this product. The data from the apps will be received by the Arduino board, which will then process it. The controls of the Electric door strikes will be determined by the command. The Bluetooth Module is used to communicate between the Arduino Board and the Android Phone. The electric door strike is turned off and on by the switch when it receives an instruction from the Arduino Board. The user interface for this system is the smartphone app, which is used to configure the system's operations and manage the lock.

Real Time Smart Door System for Home Security is presented by Burak et al. [13]. The system makes advantage of video technological advancements and the Raspberry Pi as a security and safety tool for identifying and visualizing visitors to the house. The research employs two distinct technologies (Video and Smart Phone). The video was used to keep a real-time eye on the front entrance, while the phone server served as a voice communication tool. The study's system provides users with a number of advantages, including knowing who is at the door without having to open it, streaming of activity behind the door, and so on. The system's fundamental flaw is the high cost of real-world implementation.

According to Nehete [14], door lock security systems are classified as I Password based, (ii) Biometric based, (iii) GSM based, (iv) smart card based, (v) RFID based, (vi) Door phone based, (vii) Bluetooth based, (viii) Social networking sites based, (ix) OTP based, (x) VB based, (xi) Combined system. Fig. 1 illustrates this.

Mehedi et al., [15] presented a versatile security and alarm system which can be used by individuals, corporations and establishments which require a cheap but reliable security system. The idea behind this project is to provide its users with a simple, fast and reliable way to get help during emergency situations. The device can be placed at any remote location which can be easily accessed by the user. It uses a microcontroller for system control, GSM technology for communication and sends SMS containing the emergency message and the GPS location of the sender. The project consists of an 8-bit microcontroller ATmega16, GSM SIM900A module and two Android applications for user interface with the hardware. One of the application configures the device. On pressing the panic button, the emergency contact receives the emergency message along with the GPS location of the sender. The device has been made for less than 1300INR and it can be used anywhere irrespective of the place of deployment provided mobile network connectivity is available.

Djupsjo and Almosawi [16] developed an IoT application based on digitizing a smart door lock

and connecting it to the internet so that it can recognize employees who work in the workplace. In their experiment, the Particle Photon Microcontroller was used as the microcontroller to manage both WiFi and Bluetooth connectivity in a proposed test environment. The architectural plans for the built Android-based application are chosen. A detailed description using a multi-master database (Azure Active Directory) and a novel technology called Eddystone as the Bluetooth beacon transmission mechanism. The Android application that was developed resulted in a secure and effective IoT infrastructure. Although the system's components have a high level of cohesion, its ability to adopt an alternate workflow is limited, which can result in unresponsiveness if error callbacks are missing. Furthermore, system control is limited, and it can only operate to its full potential within limited Wifi and Bluetooth coverage. When compared to the biometric authentication used in this study, relying just on a password or token as a credential for authentication could be easily abused.

Oduroye et al. [17] developed a voice recognition-based door access control system that allows individuals to unlock their doors quickly while also ensuring their safety and security. The testing phase and the training phase are the two phases of the system. The training phase involves extracting and storing properties from a speech in a database. During the testing phase, voice recognition algorithms would extract the intents from a person's speech and match them to voice models. If a match is found, the user is given permission.

Muneer et al., [1] created a GSM module that allows authorized owners to receive a randomly generated password as a security measure. The primary goal of this design is to improve or optimize the overall performance of traditional security doors such as sliding doors, panel doors, and revolving doors. The testing findings demonstrate the system's efficiency in terms of electricity generation and the time required to verify the property owner's identity. The power generator, for example, can generate electricity faster, whereas the time it takes to acquire a security code on a mobile device is roughly 3.6 seconds.

4. METHODOLOGY

4.1 Principle of Operation

The voice-controlled door is built around a microcontroller (ATmega328p), and it is designed to output a voice message based on the input data. A speech recognition module, serves as the means through which the owner or user can access the door. To access the door, the owner needs to pronounce the particular speech or key word required to unlock the door. If the pronounced word does not match the speech recognized by the microcontroller, a voice notification is then outputted through the attached speaker. A red-light emitting diode will glow to indicate that access is denied. If the pronounced speech matched, the microcontroller would activate a relay and current flows through the latch which enables the door to be unlocked. The flow diagram of Speech Controlled Door is as shown Fig. 2 while the circuit diagram is displayed in Fig. 3.

4.2 Hardware Components

1. Microcontroller (ATmega328p)
2. 16MHz crystal oscillator
3. 28 pin IC socket
4. Capacitor
5. Resistor
6. Voice recognition module (VR3)
7. 7805 voltage regulator
8. LM317 voltage regulator
9. Speaker
10. Diode
11. Printed circuit board
12. Power supply
13. Latch

4.3 The Voice Recognition Module

For this design, the Geetech Voice Recognition Module version was used for the voice recognition stage of this design. The voice recognition module is a compact and easy control speaking recognition board. This product is a speaker-dependent voice recognition module. It supports up to 80 voice commands in all.

Max 7 voice commands could work at the same time. Any sound could be trained as command. Users need to train the module first before letting it recognize any voice command.

This board has 2 controlling ways: Serial Port (full function), General Input Pins (part of function). General Output Pins on the board could generate several kinds of waves while corresponding voice command was recognized.

4.4 LATCH

Latch is a fully integrated hardware and software solution that can deliver a full-building experience with building automation systems from Latch. The present invention is to determine the opening and closing of the door by detecting the movement position of the latch (LATCH) with a sensor (led), but to open the door using a voice synthesis device to alert the voice (voice message).

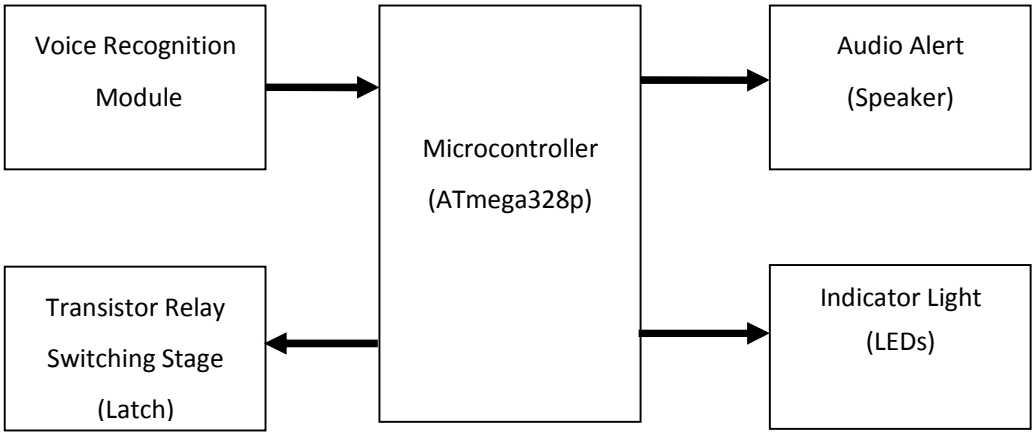

Fig. 2. Block diagram of speech controlled door

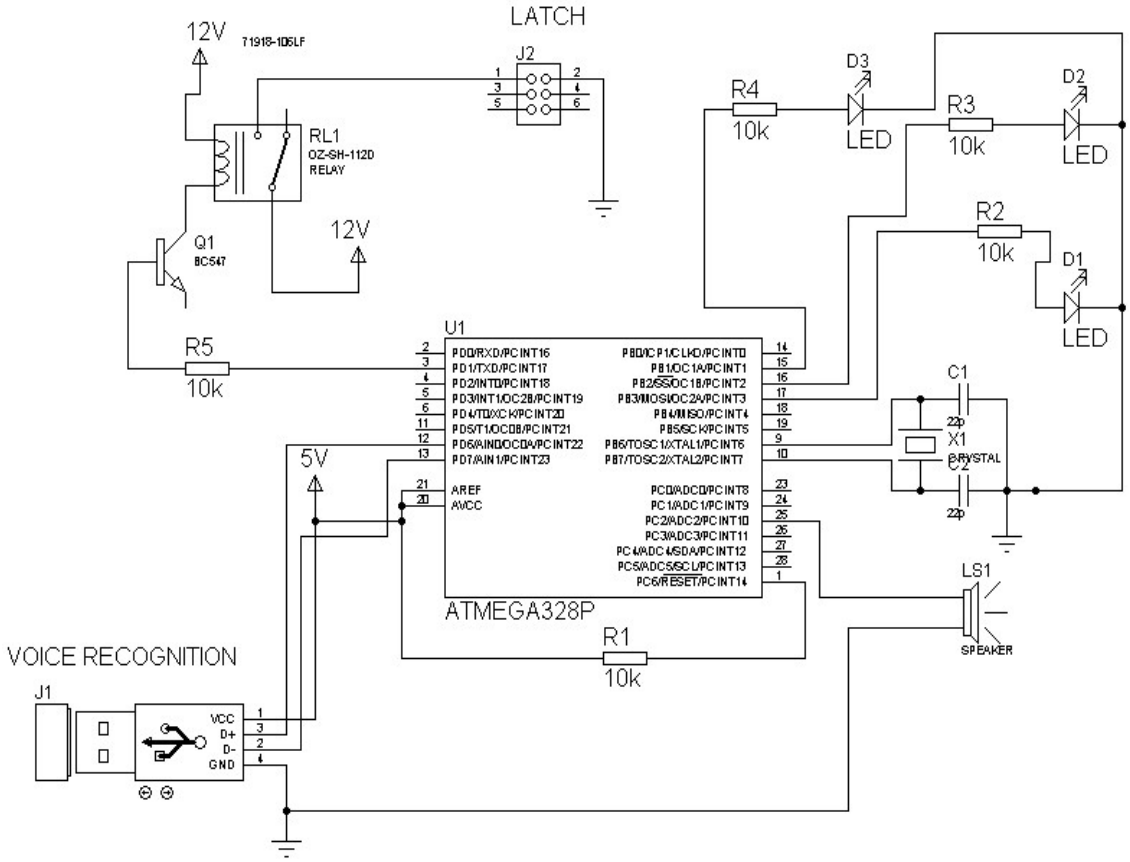

Fig. 3. Circuit diagram of speech controlled door

In general, the latch mounted on the door part of the system is a mechanism for opening / closing the door by combining the striker with the first and second stages to prevent the passengers' safety and theft of the vehicle. LATCH detects the opening or closing of the door and detects the opening or closing of the door, and when the door is detected to be open or not closed, the door is opened to alert the opening of the door by voice.

Voice by synthesizing the voices of the door setting unit for setting the door position by using the DIP switch, the voice memory unit storing the voice data, and the voice memory unit related to the door when the door opening signal is input. Synthesis and control unit, amplification unit for amplifying and outputting the speech signal output from the speech synthesis and the control unit with a large force signal, and the amplified signal. It is composed of speakers that convert to sound.

4.5 Choice of Microcontroller

Various factors were considered in the choice of microcontroller to use for this particular purpose. These include:

1. The number of digital inputs, analogue inputs the system concerned requires; a factor which helps to determine the minimum number of inputs and outputs (I/O) that the chosen microcontroller must have and the extent of need of an internal analogue to digital converter module.
2. The size of program memory storage required
3. The magnitude of clock frequency; a factor which determines the execution rate of tasks by the microcontroller
4. The number of interrupts and timer circuits required.

In a project of this kind where the communication between the controller and the voice recognition module is largely dependent on the amount of memory available, a microcontroller with a large memory sufficient input/ output ports and analogue/digital channels such as the ATMega328P is quite acceptable for use.

4.5.1 The ATmega328p microcontroller

ATMEGA328P is high performance, low power controller from Microchip. ATMEGA328P is an 8-bit microcontroller based on AVR RISC architecture. It is the most popular of all AVR controllers as it is used in ARDUINO boards.

4.5.2 Major blocks in the AVR MCU

The major parts of the AVR MCU (Microcontroller Unit) are the program memory, data memory which is also called file register (SRAM), the working register, and finally the EEPROM memory section.

1. Program Memory: 32kB flash
2. Static RAM (SRAM): 2KB
3. EEPROM Memory: 1kBytes EEPROM
4. Working Register: Byte wide used in most instructions
5. Latch: The latch, which is a spring-loaded bolt that is found within the locking mechanism of the doorknob and the deadbolt.
6. Speaker:
7. Light Emitting Diode : To indicate if the door was open

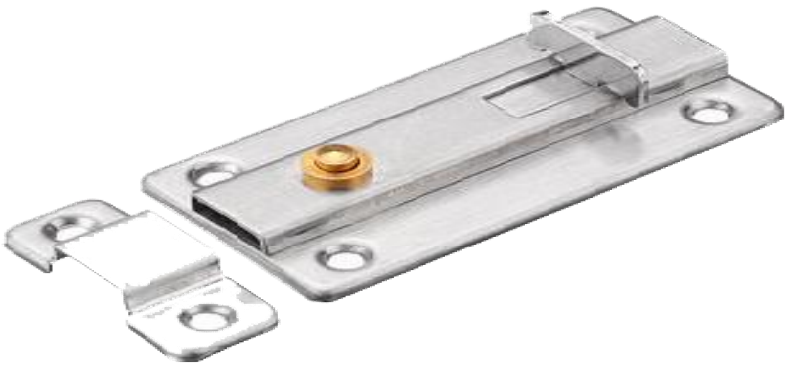

Fig. 4. Latch

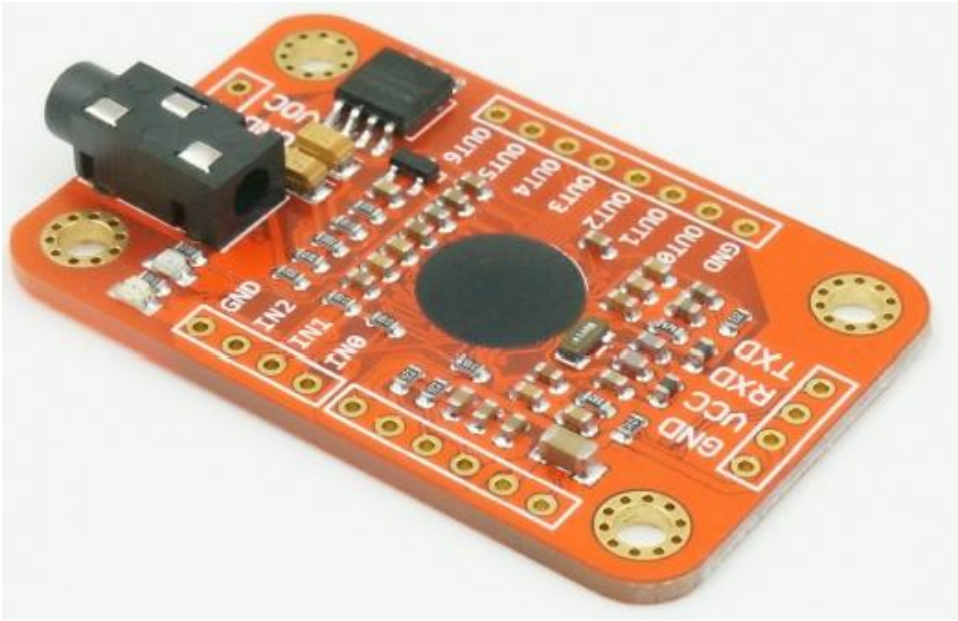

Fig. 5. Geetech speech recognition module

Fig. 6. Microphone

Table 1. ATmega328p features

ATMEGA328P – Simplified Features	
CPU	8-bit AVR
Number of Pins	28
Operating Voltage (V)	+1.8 V TO +5.5V
Number of programmable I/O lines	23
Internal Oscillator	8MHz Calibrated Internal Oscillator
Program Memory Type	Flash
Program Memory or Flash memory	32Kbytes[10000 write/erase cycles]
CPU Speed	1MIPS for 1MHz
RAM	2Kbytes Internal SRAM
EEPROM	1Kbytes EEPROM
Program Lock	Yes
Operating Temperature	-40°C to +105°C(+105 being absolute maximum, -40 being absolute minimum)

5. IMPLEMENTATION AND TESTING

The physical realization of the project is very vital. Here the paperwork is transformed into a finished hardware. After carrying out all the paper design and analysis, the project was implemented, constructed and tested to ensure its working ability. The construction of this project was done in three different stages.

1. The implementation of the whole project on a solder-less experiment board.
2. The soldering of the circuits on printed circuit boards.
3. The coupling of the entire project to the casing.

5.1 Implementation

The implementation of this project was done on the breadboard. The power supply was first derived from a bench power supply in the workshop. To confirm the workability of the circuits before the power supply stage was soldered. The implementation of the project on bread board was successful and it met the desired design aims with each stage functioning as designed.

5.2 Soldering

The various circuits and stages of this project were soldered in tandem to meet desired workability of the project. The microcontroller stage was first soldered before the, voltage regulator stage and relay stage. The soldering of the project was done on a printed circuit board. The PCB was made from a copper clad board.

5.3 Casing and Boxing

The third phase of the project construction is the casing of the project. This project was constructed with wood. The entire circuit was placed inside the wooden structure.

Fig. 7. Casing and boxing

Fig. 8. The internal components of speech controlled door prototype

5.4 Testing

Stage by stage testing was done according to the block representation on the breadboard, before soldering of circuit commenced on printed circuit board. The process of testing and implementation involved the use of some test and measuring equipment's stated below.

1. **5v AC – DC Adaptor**: This was used to supply voltage (5VDC) to the various stages of the circuit during the breadboard

test. Also during the soldering of the project the 5v adaptor was still used to test various stages before they were finally soldered.

2. **Digital Multi-meter**: The digital multi-meter basically measures voltage, resistance, continuity, current, frequency, temperature and transistor.. The process of implementation of the design on the board required the measurement of parameters like, voltage, continuity, current and resistance values of the components and in some cases frequency measurement. The digital millimeter was used to check the output of the power supply used in this project.

5.4 Problems Encountered

Like every research and practical engineering work, diverse kinds of problems are often encountered. The problems encountered in this project and how they were solved and maneuvered is listed below.

1. At switching to power the device, the voice recognition module failed to respond. This problem was traced to wrong connection in the hardware. The connection was however corrected and the module responded successfully.
2. The voice recognition module couldn't communicate with the microcontroller. The problem was traced to incorrect programming code. The code was later corrected then communication was success.
3. Difficulty in training the voice recognition module due to the micro-phone attached to the module. The sensitivity of the micro-phone was not enough to interpret the right speech. There was needed to get a better micro-phone which later solved the problem.
4. An mp3 player module which was to provide a welcome and goodbye message got burnt during the course of soldering components on the board. This lead to a change to another alternative which is the Arduino Talkie library.

6. CONCLUSION AND RECOMMENDA-TIONS

6.1 Conclusion

The project which is the design and construction of voice-controlled door lock was designed considering some factors such as economic application, design economy, availability of components and research materials, efficiency, compatibility and portability and also durability. The performance of the project after test met design specifications. However, the general operation of the project and performance is dependent on the user who is prone to human error such as entering wrong data.

Also the operation is dependent on how well the soldering is done, and the positioning of the components on the printed circuit board. If poor soldering lead is used the circuit might form dry joint early and in that case the project might fail. Also if logic elements are soldered near components that radiate heat, overheating might occur and affect the performance of the entire system. Other factors that might affect performance include transportation, packaging, ventilation, quality of components, handling and usage.

The construction was done in such a way that it makes maintenance and repairs an easy task and affordable for the user should there be any system breakdown. The project really gave a good exposure to digital and practical electronics generally which is one of the major challenges in this field now and in future. The design of the voice-controlled door lock system involved research in both digital and microelectronics. The project was quite challenging and tedious but eventually was a success.

6.2 Recommendation

For future research, the following areas were highlighted for this purpose. The whole circuitry can be reduced by making use of integrated circuit with higher scale of integration, a higher scale integrated circuit can be used so that other means of authentication could be used to cut across to the less privileged in the society (e. g. visually impaired individual), it can become a smart door by adding other features like, camera, sms communication and changing the speech used in unlocking the door and can be improved from being a prototype to a real door that can be used to replace existing doors in offices and lecture rooms.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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