

# A GLOVE BASED SYSTEM FOR HEARING IMPAIRED VICTIMS

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## ABSTRACT

Deafness is defined as a partial or complete hearing loss. Deafness can be present at birth (congenital), or become evident later in life (acquired). In general, people with hearing impaired and speech disability use sign language based on hand gestures with a specific motion to represent the language they are communicating. A gesture in a sign language is a precise movement of the hands with a specific shape from the fingers and whole hand. This work aims to design a portable embedded system that will convert the sign language into voice.

The system is divided into two main units. The RF transmitter unit that transmits a wireless RF transmitter signal to the receiver unit, and the receiver unit that receives the wireless command from the RF transmitter unit. The RF transmitter unit consists of components like; ADXL335 accelerometer that serves as the hand gesture sensing unit, a microcontroller that controls all the peripheral components that are attached to it and the RF transmitter module. The receiver unit consists of components like; RF receiver module, LED's that serves as voice output indicators, microcontroller and audio amplifier that amplify the voice outputs.

Four voice outputs results were being obtained from four different wrist motions using a LED's as the voice indicator. The blue LED represent "I am hungry" as the voice output, the dark red LED represent "I am tired" as the voice output, the green LED represent "I am sick" as the voice output and the red LED represent "I am thirsty" as the voice output.

**Key words:** *Glove based system, Sign language, Gesture recognition, and Accelerometer.*

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# 1. INTRODUCTION

Deafness is simply define as partial hearing or complete hearing loss. Deafness can either be congenital i.e. present at birth, or acquired i.e. becoming obvious later in lifetime.

The major effect of deafness is the difficulty of the victim to communicate with others. Sign language is been regarded as the communication tool used by the hearing impaired victims to communicate, but so often, in most developing countries like Nigeria, sign language development or teaching is been delayed mostly in children with unaddressed hearing loss. Furthermore, sign language is not easy to acquire because of its difficulty due to its differences in sentence and grammar formation. Figure 1 represents all sign language gestures made by hearing-impaired victims.

Furthermore, this difficulty of sign language understanding leads to a large barrier in communication between the hearing impaired victims and normal people. This problem in most cases in Nigeria put this category of people (hearing impaired) in a serious problem, especially when they need urgent assistance from people in the hearing world. This condition may continue if sensible efforts are not made and this can negatively impact on the economy of the nation. This communication breach between the deaf people and their instantaneous communities in Nigeria cannot be exaggerated.

Statistics show that 23.7% of Nigerians have a hearing impairment (total deafness, hearing loss, or other hearing-related impairment) in a country of more than 155 million people (Eleweke, 2015).



Fig 1: Sign language(Kanika, 2016).

Nevertheless, communication is of utmost importance in the current data-driven society that we are, not only in great situations but so often in our day to day activities. Shopping at a supermarket, asking for directions, making an emergency request (e.g. I am thirsty, I am sick, I need your help) depend on reliable communication. Hearing-impaired victims usually face the challenge of communicating orally which cause a delay in their interaction with the normal people.

Moreover, there is a lot of different sign language across the world e.g. American sign language, British sign language, Nigerian sign language etc. The American sign language is among the most popular sign language used in the world.

It is amazing that in a country like Nigeria that relies seriously on the exchange of information for development, not enough attempts have been made to overcome this communication barrier among the deaf community. Therefore, there is a need to develop a system which can assist in

translating the sign language into voice to ensure that effective communication can easily take place among the Nigerian people.

This work aims to design a portable embedded system that will help speech defective and hearing-impaired victims to communicate with people using their sign language.

## **2. LITERATURE REVIEW**

Different types of glove systems were been made and commercialized over the years. The first glove prototypes include the Sayre glove, the Massachusetts Institute of Technology (MIT) LED glove and the digital entry data glove. The Sayre glove was developed in 1977 by Thomas Defanti and Daniel Sandin based on the idea of Rich Sayre. It used flexible tubes with a light source at one end and a photocell at the other, which were mounted along with each hand of the glove. As each tube was bent, the amount of light passing between its source and photocell decreased. Thus, the voltage from each photocell could be correlated with finger bending. The MIT-LED glove was developed at the MIT media laboratory in the early 1980s as part of a camera-based LED system to track body and limb position for real-time computer graphics animation. It used LEDs studded on a cloth (Zeltzer, 1994).

Furthermore, an attempt will be made to describe systems that have been designed for hearing impaired patients and the limitations associated with these systems. Table 2.1 reports a list of glove characteristics typically reported in the literature for technical comparison purposes, such as sensors specifications, external connections as well as a list of their applications.

Table 2.1: List of glove characteristics for technical comparison.

Device	Technology	Application	Advantage	Disadvantage
SIGMA gloves(Williams, 1998)	Carbon ink bend sensors	Medicine, Rehabilitation, Analysis of motor performance.	Easy donning for disabled users, available in three sizes.	Scarce literature.
Swedish glove (Karlsson, 1999)	Air pressure and capacitive sensor	Robot control and tele-operation	Low cost.	Low precision, scarce literature, not suitable for complex posture recognition, calibration required for new users.
Accele-glove (Lindeman, 2002)	Dual-axis accelerometers	Sign-language understanding	No calibration, low cost.	Cannot recognize horizontal posture.
Cyber gloves(Coiffet, 2003)	Piezo-resistive	Sign-language understanding, Entertainment, Analysis of motor performance, Robot control and tele-operation	A large amount of literature, the wireless version available, equipped with abduction-adduction sensors.	One size available, difficult recording from the thumb, calibration required for new users, expensive.
Data gloves(Aditi, 2013)	Fibre optic	Sign-language understanding, Medicine,	A good amount of literature review.	Difficult recording from the thumb, calibration required

		Rehabilitation, Entertainment, 3D modelling, Robot control and tele-operation.		for new users, non-linear mapping between joint movement and intensity of reflected light, no abduction-adduction sensor, sampling inadequate for time-critical applications.
Didji glove (Ankit, 2014)	Capacitive sensors	Entertainment.	Available in left and the right model.	Scarce literature, calibration required for new users.
Acceleration sensing gloves (Rakesh, 2017)	Accelerometers	Sign-language understanding	Wireless version available.	Scarce literature.

Moreover, the hearing impaired victims use not only their fingers to communicate, but they also make use of the motion of their wrist to communicate. We have at least six types of wrist motion that we use in communication as shown in figure 2. These types of wrist motion include:

- Abduction
- Adduction
- Extension
- Flexion
- Pronation
- Supination

For this work, our contribution to Nigerian deaf community relies on the wrist motion. Figure 2 represents the 6 different types of wrist motion.

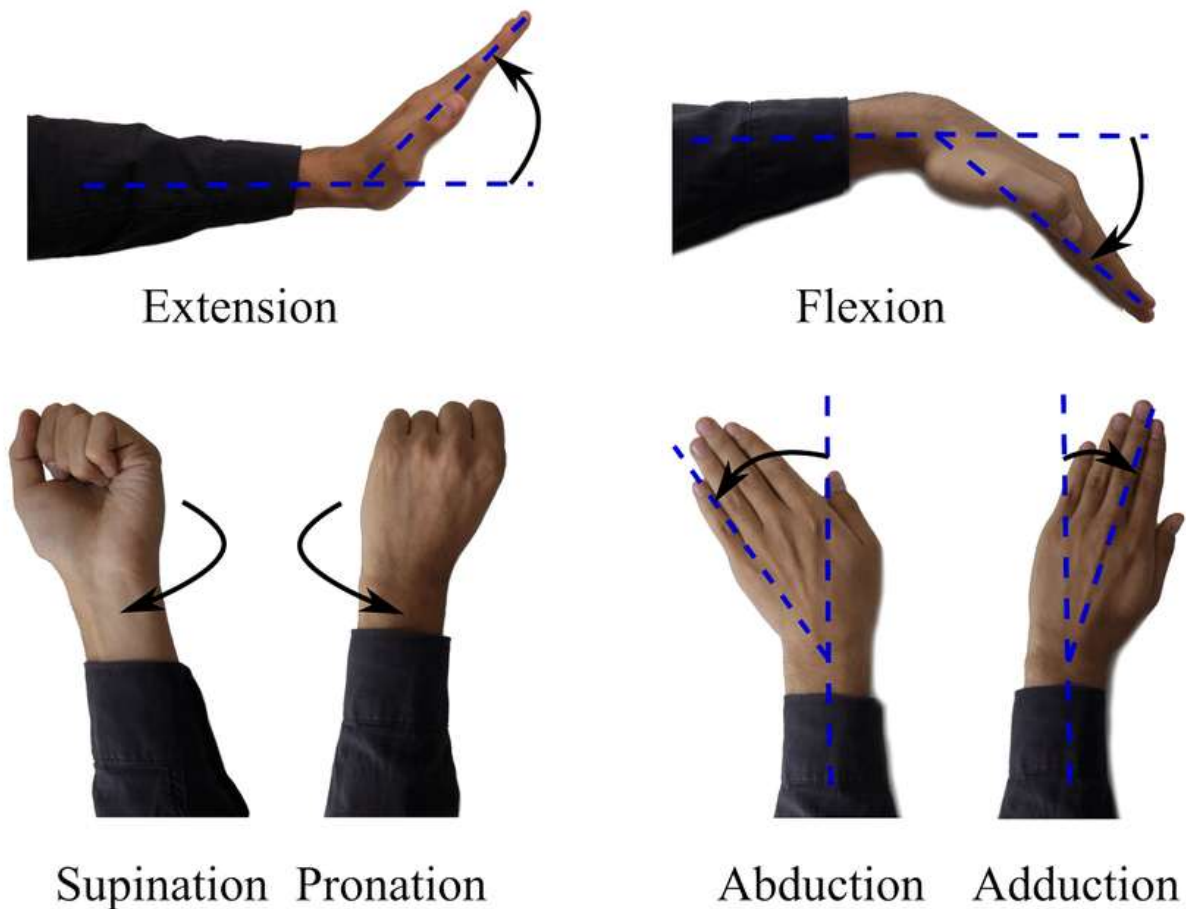


Figure 2: Wrist joint motion (Watanabe, 2008)

### 3. SYSTEM ARCHITECTURE (METHODOLOGY)

In an attempt to implement the proposed system, the system is divided into two modules which are the hardware and software design considerations. The hardware module consists of:

- Power supply unit.

- Transmitter unit.
- Receiver unit.

Figure 3 illustrates the system block diagram

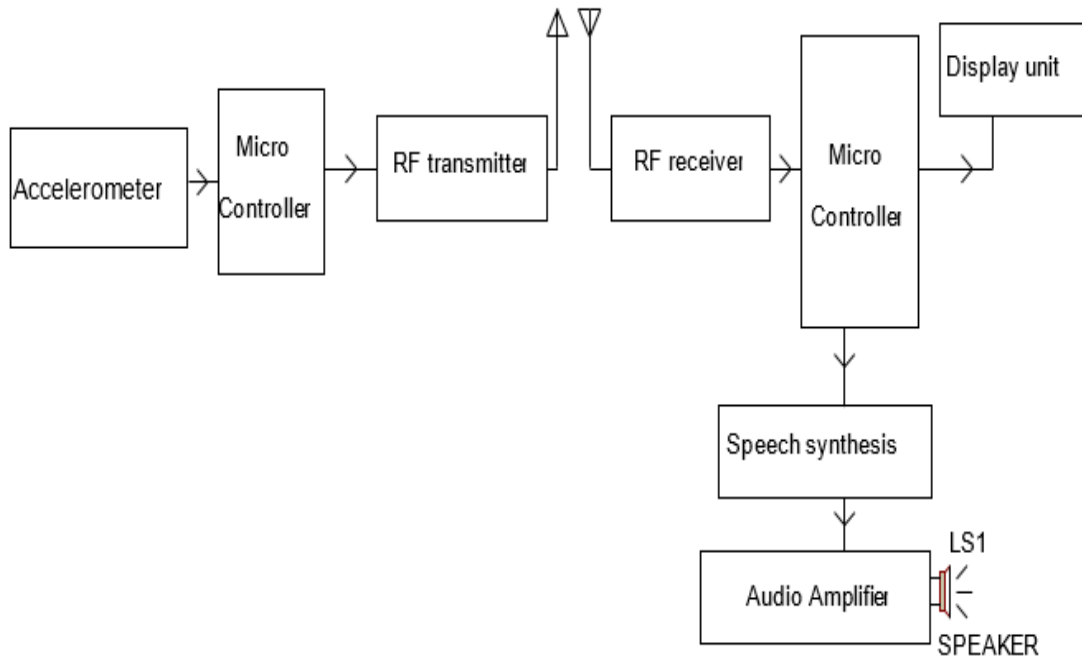


Figure 3: System block diagram

The basic components of the glove based system were given below:

- **Accelerometer:** This serves as the hand gesture sensing unit. It can measure the static acceleration of gravity in tilt-sensing applications, as well as dynamic acceleration resulting from motion, shock, or vibration.
- **Microcontroller:** This controls all the peripheral components in the two units i.e. both transmitter and receiver unit.



- RF transmitter module: The RF transmitter unit transmits a wireless RF transmitter signal to the receiver unit.
- RF receiver module: The RF receiver unit receives the wireless command signal from the RF transmitter unit.
- Audio amplifier: The audio amplifier amplifies the voice output
- Light-emitting diodes LED's: The LED's serves as different voice output indicators

### 3.2 Hardware implementation

#### 3.2.1 Power supply unit

The power source is one of the most essential parts of this work. The operating voltage of the circuit is 9Vdc regulated power supply for both the transmitter and receiver unit. The power supply unit used a battery of 9V as shown in figure 3.1.

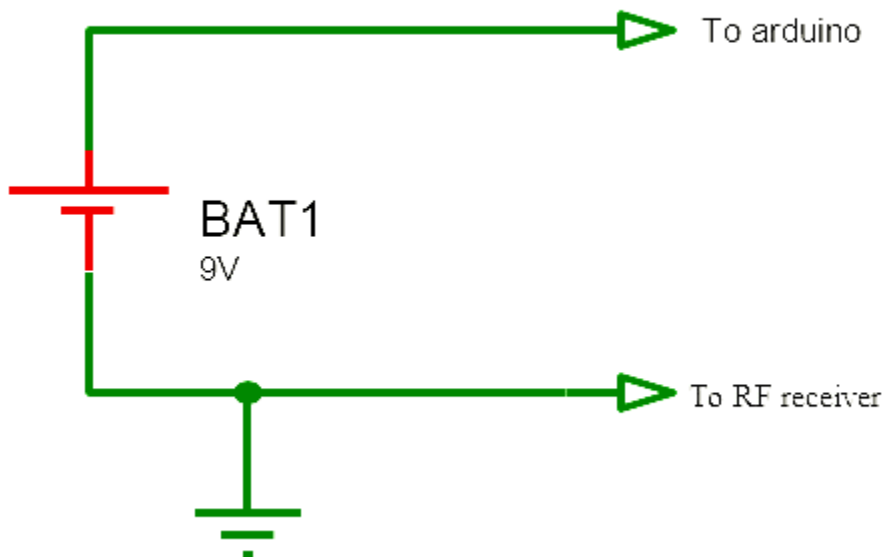


Figure 3.1 Power supply unit

### 3.2.2 Transmitter unit

This unit used to send the wireless RF transmitter signal in amplitude-shift keying (ASK) mode for the receiver unit. The arduinouno (microcontroller), RF transmitter module and ADXL335 accelerometer module achieve this unit. Figure 3.2 illustrates the RF transmitter circuit interfering with the microcontroller.

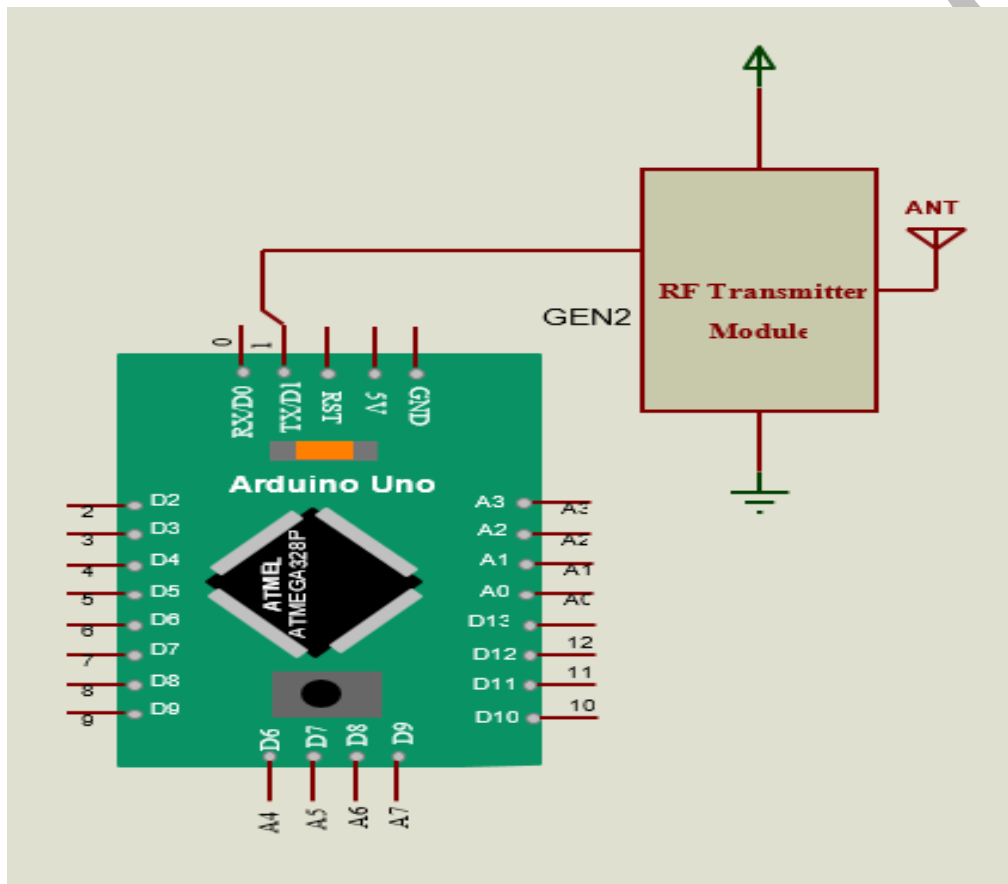


Figure 3.2: RF transmitter circuit

### 3.2.3 ADXL335 accelerometer module

The ADXL335 accelerometer which serves as the hand gesture sensing unit is a small, thin, low power and complete three-axis accelerometer with signal conditioned voltage outputs. The Accelerometer is connected to analogue ports of the microcontroller as shown in figure 3.3.

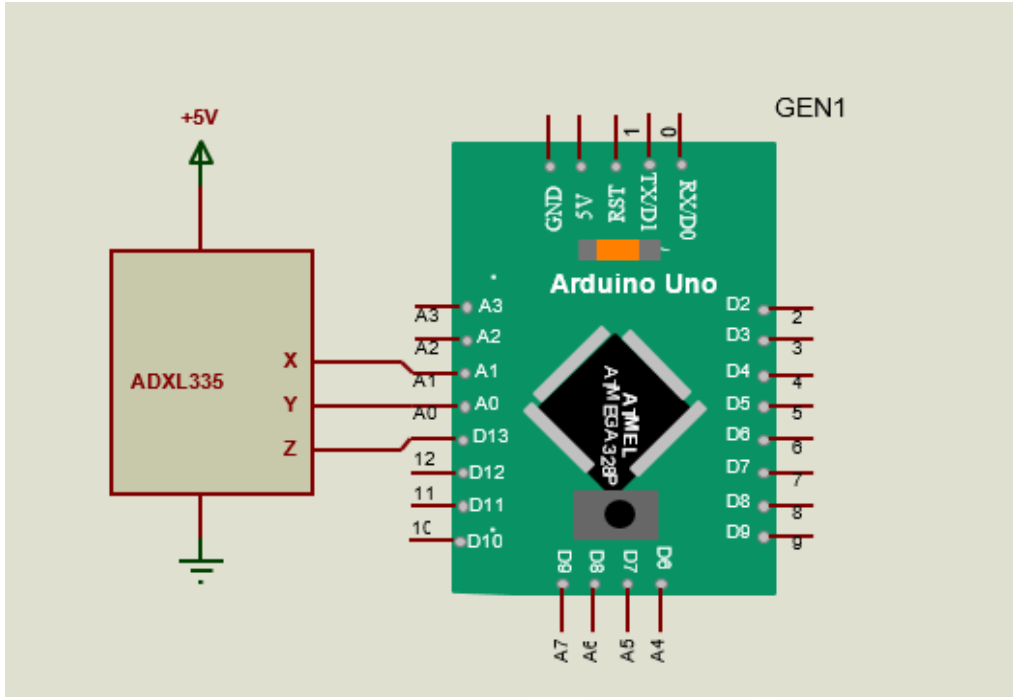


Figure 3.3 Microcontroller with ADXL335 circuit.

### Measuring hand tilt using the ADXL335 accelerometer

The ADXL335 accelerometer has 3 output pins represented as X, Y and Z axis as shown in figure 3.3. The following equations were been used to obtain different hand tilt(Luczak, 2014).

$$R_X = \frac{\left(\frac{V_X \times V_{ref}}{2^{n-1}}\right) V_0}{V_{sensitivity}} \quad (4)$$

$$R_Y = \frac{\left(\frac{V_Y \times V_{ref}}{2^{n-1}}\right) V_0}{V_{sensitivity}} \quad (5)$$

$$R_Z = \frac{\left(\frac{V_Z \times V_{ref}}{2^{n-1}}\right) V_0}{V_{sensitivity}} \quad (6)$$

$$R = \sqrt{R_X^2 + R_Y^2 + R_Z^2} \quad (7)$$

$$a = \cos^{-1} \frac{R_X}{R} \quad (8)$$

$$b = \cos^{-1} \frac{R_Y}{R} \quad (9)$$

$$c = \cos^{-1} \frac{R_Z}{R} \quad (10)$$

From the above equation,  $R_X$  represents the angle of the X-axis relative to the ground,  $R_Y$  represents the angle of Y-axis relative to the ground and  $R_Z$  define the angle of the Z-axis relative to gravity

### 3.3 Receiver unit

This unit is used to receive the wireless command from the RF transmitter unit. The arduinouno, RF receiver module, amplifier and display unit achieve this unit as shown in figure 3.4.

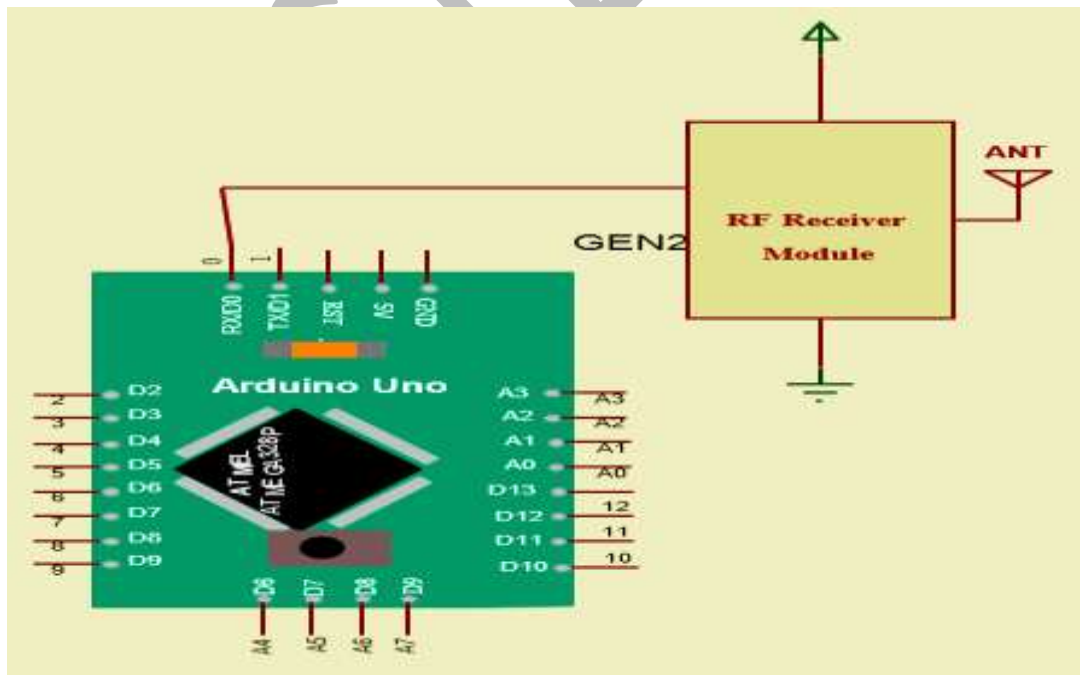


Figure 3.4: RF receiver unit circuit

### 3.3.2: Amplifier unit

This unit used to amplify the signal from SYN6288, for reading a voice to the human hearing when a dumb person communicates using a hand. The LM386 is employed to achieve this unit with a C3 capacitor for controlling the gain of the amplifier as shown in figure 3.5.

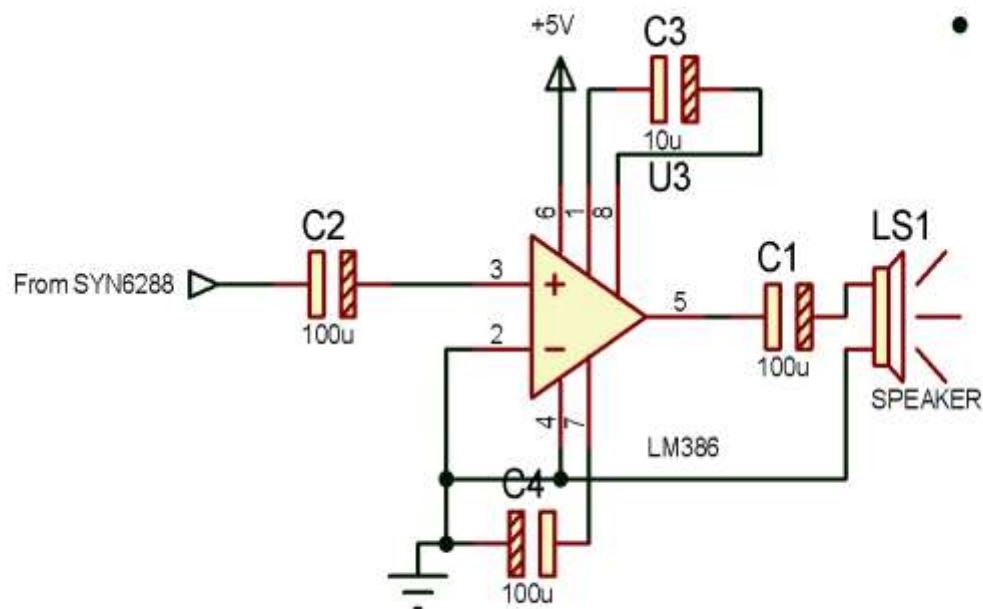


Figure 3.5 Amplifier circuit

### 3.3.3 Display unit

This unit serves to display the voice indicator from the particular four positions and the main function of the project as shown in figure 3.6

From ATMEGA 328P

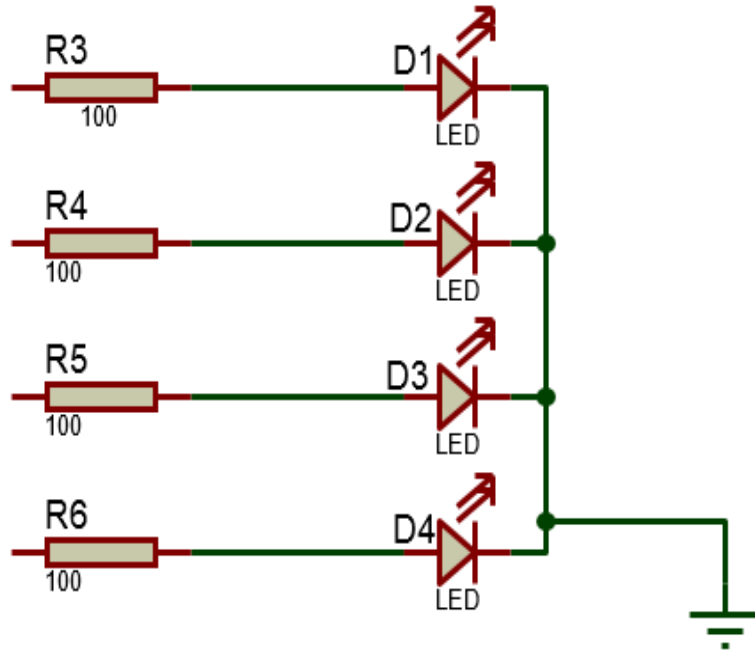
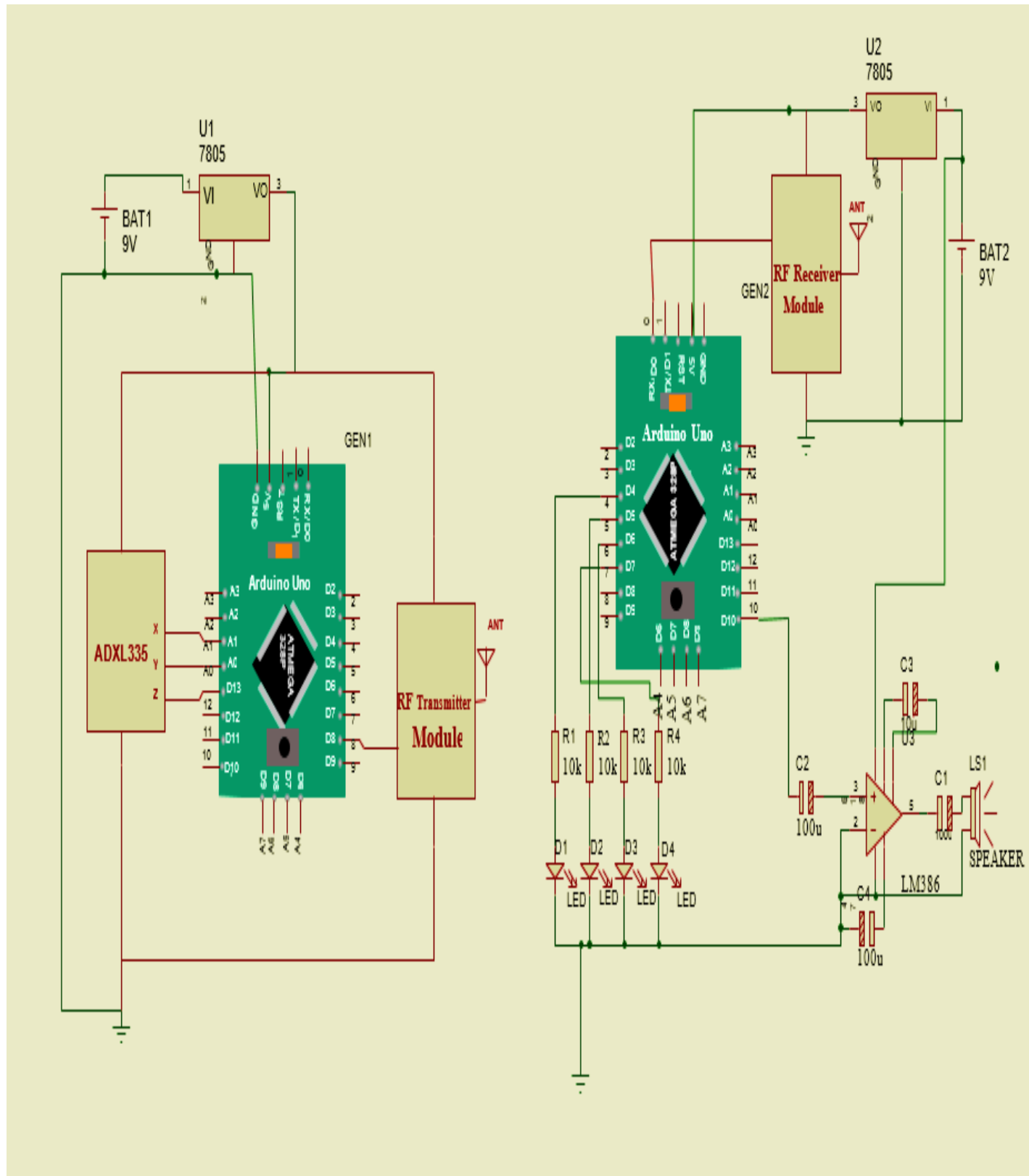


Figure 3.6 Display unit circuit

### 3.4 Software implementation

The software refers to the program code that is loaded onto the microcontroller (arduino) program memory. It is the execution of the instructions contained therein that aids the microcontroller in carrying out its primary functions of the peripheral device attached to it. The program is usually written in C language and then translate to generate a hexadecimal code file (machine code). The code block arduino compiler was used for developing C language and debug into machine codes. The implementation is carryout using arduino IDE.

The arduino IDE (Integrated Development Environment) is a cross-platform application written in java and is derived from the IDE for processing programming language and writing this prototype.



**Figure 3.7: Complete system circuit diagram**

## **4.0 RESULT AND DISCUSSION**

The preceding chapter three describes the design procedures and operation of various units of the glove based system and how the components are interconnected to make up the system from the circuit diagram in figure 3.7. This chapter however basically deals with the construction and testing of this device.

### **4.1 Construction**

The main constructional elements of the circuit are; the transmitter includes ADXL335 sensor, Rf transmitter, battery, 7805, arduino, resistors and capacitors. For the receiver side and others, unit includes Rf receiver, arduino, lm386, speaker and other discrete components such as a diode, capacitor, resistor etc.

#### **4.1.1 Arrangement of the circuit component**

There are five stages in which the first stage are assembled at separate project board while the remaining four stages involved in the assembling of circuit components. These are testing of the components, the arrangement of the components in the position, soldering and final testing to confirm or satisfy the desired result.

#### **4.1.2 Soldering**

Soldering is a process of joining two or more metals together by application of heat and solders to the joint. A correctly made joint possess a low resistance which gives good electrical continuity and has a fair degree of mechanical strength in a soundly made joint, the parts to be joined are linked by a thin film of solder which has to punctuate into the surface of each metal.



#### **4.1.3 Assembling of components on Vero-board**

The laying out of components was first done on the project board (breadboard) as a temporary circuit layout to ascertain that the circuit diagram for the construction works effectively. The correction was made during the construction on the project board before it was transferred to the vero board with fine soldering as a permanent construction. Care should be taken not to allow the soldering iron to be too hot as it can damage some components such as IC mounted on IC holder, transistor etc. All distance connection was made using connection wires.

#### **4.1.4 Construction equipment**

The following are the equipment or tools used during construction:

- i) Soldering iron, Lead, Connecting wire, Site cutters, Project board (breadboard), Vero board and Brush.

#### **4.1.5 Casing**

The mini plastic case was used for both the transmitter and receiver unit. Moreover, in the receiver units, the plastic casing is used with little construction on it to suit our application.

#### **4.2 Testing**

After completion of the construction, testing was carried out to observe the performance of the circuit. Testing was first done on each unit of the system (UNIT TESTING) before finally testing the whole system (SYSTEM TESTING).

### 4.2.1 Transmitter unit testing

The battery 9V is tested using a digital multimeter and confirmed its value. The output of amplifier gives the trigger voltage to the transmitter module at +5V. The transmitter was tested at a required distance and confirmed proper workability.

### 4.2.2 Power supply unit testing

The regulated power supply of the system was tested to ensure that the desired 5V DC was produced and how regulated the output was. Figure 4.3 shows the Graphical representation of voltage using different hand tilt.

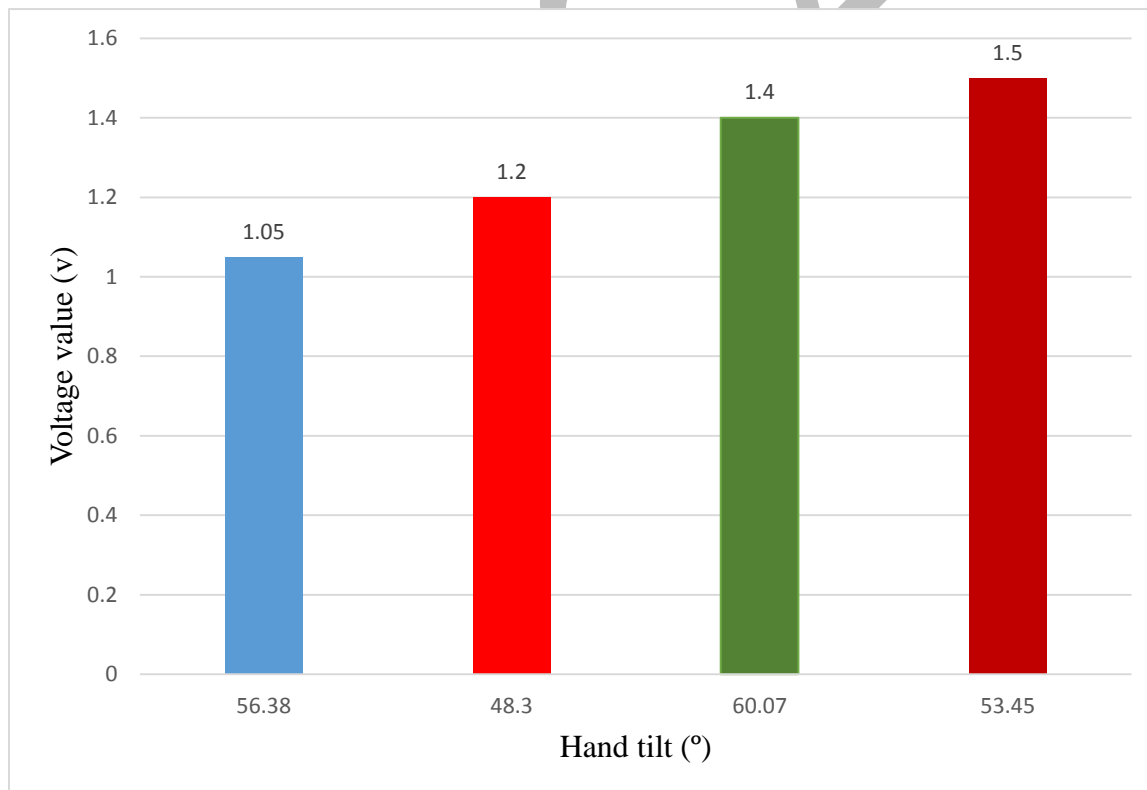


Figure 4.1 Graphical representation of voltage using different hand tilt.

### 4.2.3 Receiver unit testing

The testing carried out on this unit is to observe the sensitivity of the unit at a different distance by using an RF transmitter. Table 4.2 shows the result obtained.

Table 4.2: Wireless alarm testing

S/N	VOICE	INDICATOR
1.	I am tired	Yellow LED
2.	I am sick	Green LED
3.	I am hungry	Blue LED
4	I am thirsty	Red LED

### 4.2.4 System testing

After all the units testing have been carried out, the next is to carry out system testing i.e. when the hand move from transmitter according to table 4.2. The receiver side will respond, then the speaker will give the voice for the direction. Plate 4.1 shows the transmitter and receiver unit testing, while plate 4.2 shows the complete photograph of the project.

### 4.2.5 Testing instruments

- i) Avometer (digital multimeter)
- ii) Mastech meter

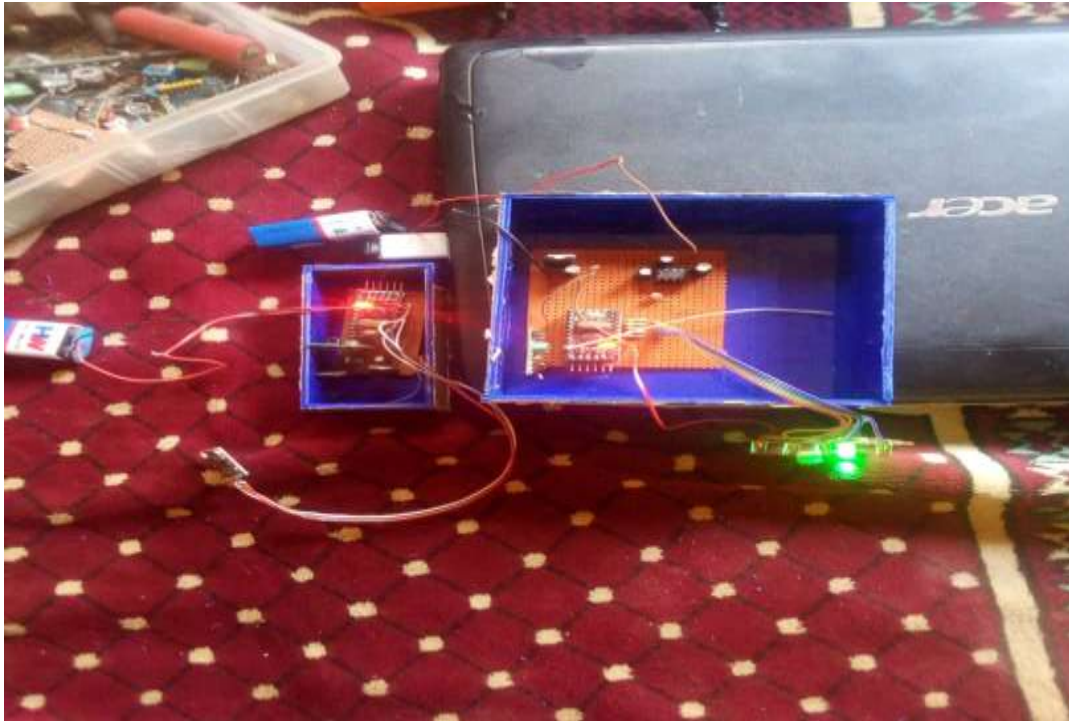


Plate 4.1: Transmitter and receiver unit testing.



Plate 4.2: Complete photograph of the project.

## 4.2 Discussion

From figure 4.1, we can see that there is different absorption of voltage from different voice output. The voice output for the wrist motion in extension position (backward wrist motion) consumes the highest voltage which is approximately 1.5V. While for the flexion position of the wrist motion, the output voltage is 1.20V. Also, for the adduction position of the wrist motion, the voltage output is 1.40V. Lastly, for the abduction position of the wrist motion, the output voltage is 1.05V. Furthermore, the different colours of the graph indicate different colours of the LED's used and each of them conveys different output message. For example, the green LED convey "I am sick" as the output voice, red LED convey "I am thirsty" as the output voice, blue LED convey "I am hungry" as the output voice and lastly the dark red LED convey "I am tired" as the output message.

The simulation as shown in figure 3.15 contain two main units, this includes the transmitter unit that comprises of components like ADXL335 accelerometer, microcontroller, RF transmitter module and other discrete components like resistors and capacitors. The second unit is the receiver unit and it contains components like RF transmitter module, microcontroller, LED as a display, speaker and other discrete components like resistors and capacitors.

As represented in chapter three, because of the lack of libraries in the proteus simulation, the actual ADXL335 accelerometer was not used instead a rectangular box was used to represent it. And also, it is noticed that it is not possible to make words in the simulation for the lack of the accelerometer library which is essential to do this.

Moreover, due to the lack of sensors libraries, simulation of the project is deficient. Also, the accuracy of the results is fairly good, but the internal resistance of the accelerometer sensor is

rapidly changing for various reasons that might be related to the low quality of the accelerometer itself or wrong usage which causes the low accuracy.

## **5.0 CONCLUSION**

This work aims to design and construct a glove based system for hearing impaired victims that are capable of being remotely detected by the dump voice selected recognition. Design criteria of such an appliance include ease of maintenance and users friendly interface. The device has less power consumption during operation. Also, instead of using the computer or the cell phone as used in the earlier inventions in this work, we make use of microcontrollers because it makes the work to be easily portable and easier to be used.

## **5.1 ACKNOWLEDGEMENT**

First of all, my gratitude goes to Allah for blessing me with the patience, strength and the ability to complete this study. I also thank my lovely parents and Kano state government for the trust and support they gave me from the very start of my study to the end. I also thank my brothers, sisters and friends, for pushing me beyond the limits I have set for myself, and for changing every "I cannot" to "I can". My sincere gratitude goes to my project supervisor Mrs Daramola for her sufficient advice, understanding and reassuring. I truly thank Mr Dele for his kindness, support, advice and consideration he gave me in my work.

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