# Tactile-Communication based Wrist-Band

A Project Report Submitted in Partial Fulfillment of the Requirements for the Degree of

**B.Tech**

**(Electronics & Instrumentation Engineering)**

*By*

**Isha Pandey**

**(BTBTN17025)**

*Under the supervision of*

**K.S. Venkatesh**

**Professor**

**IIT-Kanpur**

**SCHOOL OF AUTOMATION**
**BANASTHALI VIDYAPITH**
**BANASTHALI – 304022**

# BANASTHALI VIDYAPITH, RAJASTHAN

## SCHOOL OF AUTOMATION

## *CERTIFICATE*

*This is to certify that the "**Project Report"** submitted by **Isha Pandey (BTBTN17025)** is work done by her and submitted during 2020 – 2021 academic year, in partial fulfillment of the requirements for the award of the degree of **BACHELOR OF TECHNOLOGY in ELECTRONICS AND INSTRUMENTATION ENGINEERING (EIE),** at Banasthali Vidyapith, Rajasthan.*

**(Chandraveer Singh)**
**Assistant Professor**
**Project & Placement Coordinator**

**(Rahul Katiyar)**
**Assistant Professor**
**Project & Placement Coordinator**

**(Shailly Sharma)**
**Dean**
**School of Automation**
**Banasthali Vidyapith**

Certificate (Letter head of the organization)


IIT KANPUR

**Venkatesh K Subramanian**

DEPARTMENT OF ELECTRICAL ENGINEERING

O 206 ACES, IIT Kanpur - 208016 *(INDIA)*
R 415, IIT Kanpur - 208016 *(INDIA)*

O +91 512 259/392/679 7468/7846
R +91 512 259/392/679 8354

O +91 512 259 0063

venkats@iitk.ac.in


# CERTIFICATE

This is to certify that Ms. **Isha Pandey, (BTBTN17025)** final year student of B.Tech. (**Electronics and Instrumentation**) at **Banasthali Vidyapith, Rajasthan,** has worked on the topic **"Tactile-Communication Based Wristband".** The work reported is original and was carried out by her during the period of 6 months (Jan. 1 – Jun. 30, 2021) under my supervision at 207A/ACES, **Computer Vision Lab, Dept. of Electrical Engineering, Indian Institute of Technology (IIT), Kanpur** for the partial fulfillment of the award of Degree of **Bachelor of Technology** at her parent institution.

(K S Venkatesh)
(30/06/2021)

प्राध्यापक
PROFESSOR
विद्युत अभियन्त्रण विभाग
Department of Electrical Engineering
भारतीय प्रौद्योगिकी संस्थान
Indian Institute of Technology
कानपुर, KANPUR- 208 016

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**Isha Pandey**

# ABSTRACT

We describe the design of “The_Vband”, a device that augments remote texting communication with touch, by converting string input into vibrational intensity between users in real-time which is controlled by Bluetooth network thereby establishing a tactile internet between transmitter and receiver. The goal of this work is to enrich interpersonal communication by complementing text with a tactile channel. The device was tested on a few people to observe possible uses of the tactile channel when used in conjunction with texting. By recording and examining both texting and tactile data, we found strong relationships between the two communication channels. We demonstrate the potential of the tactile channel to enhance the existing voice communication channel.

# CONTENTS

# LIST OF FIGURES

# LIST OF TABLES

CHAPTER 1

# INTRODUCTION

**Tactile technology** is the integration of multi-sensory triggers within physical objects, allowing "real world" interactions with technology. It is similar to haptic technology, as both focus on touch interactions with technology, but whereas haptic is simulated touch, tactile is physical touch. Rather than using a digital interface to interact with the physical world, as augmented reality does, tactile technology involves a physical interaction that triggers a digital response.

Due to the broadcast nature of audio, video, texting etc., many existing communication devices compete for our attention. The senses can become overloaded and important information may be overlooked. The personal communication devices of others often needlessly interrupt our attention and compromise our privacy. One solution is to employ the underused modality of touch. The goal of this project is to design and implement a sensory augmentation tool that communicates the sense of touch. A necessary step toward this goal is to explore the possible effects of the tactile communication channel on text-based communication.

## 1.1 BACKGROUND

Mobile data communication is omnipresent. The Mobile Internet connects people anywhere and allows for voice services and the exchange of data and multimedia content at any time. Numerous innovations in the information and communication technology (ICT) sector have enabled exponential growth in network capacity, leading to the emergence of smartphones and a user-experience rich in multimedia. The Internet of Things (IoT) connects devices, or objects, to increase their efficiency by exploiting the potential of networking. The next wave of innovation will create the Tactile Internet. Extremely low latency in combination with high availability, reliability and security will define the character of the Tactile Internet. It will have a marked impact on business and society, introducing numerous new opportunities for emerging technology markets and the delivery of essential public services.

Today's fixed and mobile Internet infrastructure is typically used for transferring content from A-to-B and is optimized for the transmission of static or streaming content (e.g., e-mail, pictures, voice video). The round-trip latency of communications over existing infrastructure is sufficient for telephony, web browsing and videos with limited resolution. IoT enables the interconnection of smart devices. Typically, these devices are low-power, resource constrained sensors with limited functionality designed to transmit low-rate, latency-tolerant data. The next evolutionary leap is the Tactile Internet (Figure 1.1). The high availability and security, ultra-fast reaction times and carrier-grade reliability of the Tactile Internet will add a new dimension to human-to machine interaction by enabling tactile and haptic sensations. The professional digital infrastructure will similarly revolutionize the interaction of machines. The Tactile Internet will enable an unforeseeable plurality of new applications, products and services. It will enable humans and machines to interact with their environment in real time, while mobile and within a certain spatial communication range. As a driver of innovation, the Tactile Internet represents a revolutionary level of development for society, economics and culture.

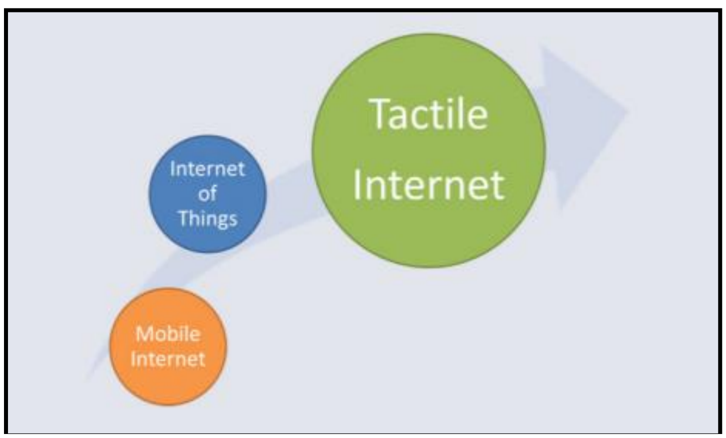

Figure 1.1: Revolutionary leap of the Tactile Internet

## 1.2 MOTIVATION

Current communications systems are part of what is commonly known as our critical infrastructure. Our society has high expectations of communications systems, demanding that they be available and dependable, protected from outside attack and free from malfunction. The technical requirements of the Tactile Communication, especially ultralow end-to-end latency, pose enormous challenges for communications systems. Paradigm changes are necessary, to ensure both data security and the availability and dependability of systems. In today's communications systems, a secure communication is based on separating the encryption from the transmission technology. Classical encryption methods provide security against eavesdropping only when the encryption algorithms are sufficiently complex and the eavesdroppers are limited in their computing power. Because these security mechanisms can only be implemented at higher protocol layers, this leads to noticeable delays. The task of the transmission technology is purely to provide high transmission rates. For the tactile communication to provide securely transmitted data with very low end-to-end latency, the security of communications against eavesdroppers and attackers must be embedded in the physical transmission. Suitable coding techniques will ensure that only legitimate receivers are able to process a secure message. The nature of a secure message is such that an eavesdropper, as an illegitimate receiver, cannot decode the data. Even with infinite computational power, an eavesdropper will not be able to decode the message. In a mathematical sense, this approach provides absolute security. The important criteria in assessing the performance of new communications systems are, among others, their maximal rates of transmission of absolutely secure messages as well as their maximal key-generation rates of absolutely secure keys and rates of transmission of absolutely secure keys. This approach – prioritizing the technical security of transmission – is superior to classical encoding methods in that physical propagation conditions directly determine the performance variables of communications systems. This permits system dimensioning and optimization to be taken into consideration.

## 1.3 PROPOSED SOLUTION

With the motivation behind our project and an objective as to create a secure transmission, we came up with a tactile-communication based wrist-band namely, "**The_Vband**" where V stands for vibration (The_Vibratoryband). For now, this band consists of 4 coin-vibrating motors; though earlier, it was supposed to be consisting of 12-14 coin-vibrating motors with a proper alignment for optimum output, but we were unable to work in IIT-K lab after covid hit for the second time, due to which we could solder only 4 of them in the due course of time. Apart from the attachment of only 4 vibrating motors, there were some proposed objectives regarding performance of the wrist-band too that could not be met due to covid. But still we managed somehow to make it work as we had thought of with those 4 motors. In addition to the 4 coin-vibrating motors, the prototype on which this project is based can be controlled from a customized mobile application through Bluetooth. The user would be able to distinguish the different vibrations, which is the actual purpose of this project, as we didn't want to make a device that can produce a vibration that can be felt easily but can be distinguished easily because different set of signals have to be sent.

The proposed device is a texter-tactile device sleeve that fits on the wrist of the transmitter and receiver. The basic concept is a handheld device that translates encoded texting consisting of alpha-numeric characters into vibration. The devices are bi-directional and both users can send and receive signals simultaneously.

The technology behind this project is based upon subsonic i.e., any speed lower than the speed of sound within a sound-propagating medium.

## 1.4 ADVANTAGES AND LIMITATIONS OF PROPOSED SOLUTION

One of the limitations of spoken communication is that it requires a reasonably low ambient noise level and there are certain situations where this can't be affordable, for e.g., places with a lot of traffic, manufacturing shops such as punching; the noise decibel level is very high and yet sometimes short critical messages need to be passed to the particular person or set of people in the environment as they may be of great importance. In the light of the possibility that the person being communicated with is not looking in your direction, one may not be able to communicate visually with him as well, this system on the other hand will work irrespective of which direction the person is looking as well as surrounding noise. It will directly be sensed by the skin and subsequently interpreted and acted upon. This is the beauty of tactile communication.

Another situation where this type of messaging can be used is to communicate with somebody who presently is not looking at a mobile phone or would not like to be seen as looking at a mobile phone but can still receive messages by means of tactile vibrations as it will be sent through a wrist band or any similar suitable prototype. These are the two use cases which can be thought of as for now.

The limitations of this project that can be expected till now is the working of the project in absence of proper Bluetooth network, in addition to it, there can be variations too among different users to identify the different vibrational modes at a particular instant of time.

CHAPTER 2

# PROTOTYPE REQUIREMENTS

As mentioned in the previous section, in order to achieve the objectives met, first of all it is necessary to establish the needs of the project.

In hardware terms the most important part is the local controller, an Arduino board, which will be the core of the application, the one that will be communicated with the mobile application and where the coin-vibrating motors will be connected.

Finally, to make effective the necessary communication between the board and the mobile will be needed a Bluetooth device.

As for software, one of the advantages of using an Arduino board as a local controller is that it has its own development environment or IDE (Integrated Development Environment) that provides facilities for software development. For the other programming part, will be necessary another software to program the mobile application.

The cloth used for the wrist band is parachute cloth so as to easily fabricate the coin-vibrating motors and connections on the same. The vibrations can also be sensed easily through the cloth.

# ARCHITECTURE AND COMPONENTS

## 3.1 ARDUINO

Arduino is a development board that integrates a microcontroller and its support circuitry with digital and analog inputs and outputs. It has an open-source computing development platform based on an environment for programs creation.

### 3.1.1 Choice of Board

Shown below there is a comparison chart with the commonly used boards for this type of application including their most important characteristics.

Table 3.1: Comparison of Arduino Boards

| Specifications | Arduino UNO | Arduino Mega | Arduino UNO Rev R3/ Pro |
|---|---|---|---|
| **Microcontroller** | ATmega 328P | ATmega 2560 | ATmega 328 |
| **Input Voltage** | 7-12 V | 7-12 V | 5-12 V |
| **Operating Voltage** | 5 V | 5 V | 5 V |
| **Output Current** | 20 mA | 20 mA | 40 mA |
| **Clock Frequency** | 16 MHz | 16 MHz | 8 MHz |
| **Flash Memory** | 32 KB | 256 KB | 32 KB |
| **SPRAM** | 2 KB | 8 KB | 2 KB |
| **EEPROM** | 1 KB | 4 KB | 1 KB |
| **Digital I/O** | 14 | 54 | 14 |
| **PMW Outputs** | 6 | 12 | 6 |
| **Analog I/O** | 6 | 16 | 6 |

As we just wanted to prototype something small, add a shield too for Bluetooth module, a cost-effective option, we went with Arduino UNO Rev R3.

### 3.1.2 Parts of Arduino UNO Rev R3 Board

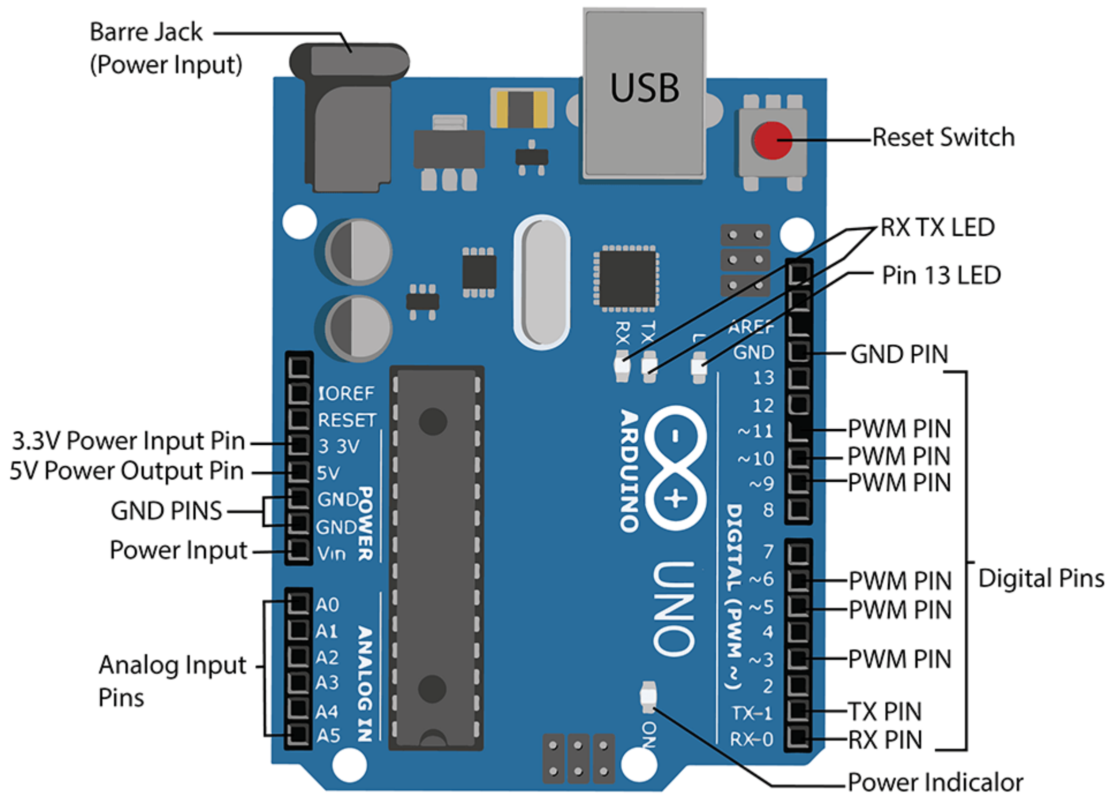


Figure 3.1: Parts of Arduino UNO Rev R3 board

➢ Parameters:

1) <u>Power</u>

The Uno can be powered via the USB connection or with an external power supply. The power source is selected automatically.

External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the Gnd and Vin pin headers of the POWER connector.

The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts.

The power pins are as follows:

- **VIN.** The input voltage to the Arduino board when it's using an external power source (as opposed to 5 volts from the USB connection or other regulated power source). One can supply voltage through this pin, or, if supplying voltage via the power jack, access it through this pin.
- **5V.** The regulated power supply used to power the microcontroller and other components on the board. This can come either from VIN via an on-board regulator, or be supplied by USB or another regulated 5V supply.
- **3V3.** A 3.3-volt supply generated by the on-board regulator. Maximum current draw is 50 mA.
- **GND.** Ground pins.

2) Memory

The Atmega328 has 32 KB of flash memory for storing code (of which 0.5 KB is used for the bootloader); It has also 2 KB of SRAM and 1 KB of EEPROM (which can be read and written with the EEPROM library).

3) Input and Output

Each of the 14 digital pins on the Uno can be used as an input or output, using pinMode(), digitalWrite(), and digitalRead() functions. They operate at 5 volts. Each pin can provide or receive a maximum of 40 mA and has an internal pull-up resistor (disconnected by default) of 20-50 kOhms. In addition, some pins have specialized functions:

- **Serial: 0 (RX) and 1 (TX).** Used to receive (RX) and transmit (TX) TTL serial data. These pins are connected to the corresponding pins of the ATmega8U2 USB-to-TTL Serial chip.
- **External Interrupts: 2 and 3.** These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value.
- **PWM: 3, 5, 6, 9, 10, and 11.** Provide 8-bit PWM output with the analogWrite() function.

- **SPI: 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK).** These pins support SPI communication, which, although provided by the underlying hardware, is not currently included in the Arduino language.
- **LED: 13.** There is a built-in LED connected to digital pin 13. When the pin is HIGH value, the LED is on, when the pin is LOW, it's off.

The Uno has 6 analog inputs, each of which provide 10 bits of resolution (i.e., 1024 different values). By default they measure from ground to 5 volts, though is it possible to change the upper end of their range using the AREF pin and the analogReference() function. Additionally, some pins have specialized functionality:

- **$I^2C$: 4 (SDA) and 5 (SCL).** Support I2C (TWI) communication using the Wire library.

There are a couple of other pins on the board:

- **AREF.** Reference voltage for the analog inputs. Used with analogReference().
- **Reset.** Bring this line LOW to reset the microcontroller. Typically used to add a reset button to shields which block the one on the board.

The Arduino software includes a serial monitor which allows simple textual data to be sent to and from the Arduino board. The RX and TX LEDs on the board will flash when data is being transmitted via the USB-toserial chip and USB connection to the computer (but not for serial communication on pins 0 and 1).

A SoftwareSerial library allows for serial communication on any of the Uno's digital pins. The ATmega328 also support I2C (TWI) and SPI communication. The Arduino software includes a Wire library to simplify use of the I2C bus.

4) USB Overcurrent Protection:

The Arduino Uno has a resettable polyfuse that protects your computer's USB ports from shorts and overcurrent. Although most computers provide their own internal protection, the fuse provides an extra layer of protection. If more than 500 mA is applied to the USB port, the fuse will automatically break the connection until the short or overload is removed.

5) Physical Characteristics

The maximum length and width of the Uno PCB are 2.7 and 2.1 inches respectively, with the USB connector and power jack extending beyond the former dimension. Three screw holes allow the board to be attached to a surface or case. The distance between digital pins 7 and 8 is 160 mil (0.16"), not an even multiple of the 100-mil spacing of the other pins.

## 3.2 COMPONENTS

### 3.2.1 Coin-Vibrating Motor

Key Features:

- Small size makes it easy to mount in or on your haptic device.
- Low noise level enables feedback without unwanted distractions.
- Rated at 3 VDC, giving us a low-power solution for haptic feedback.

Application Ideas:

- Touch screen feedback
- Simulations, mobile phones, RFID scanners, Portable instruments
- Video game and other feedback applications
- Medical applications

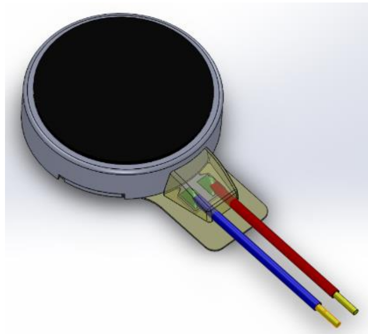

Figure 3.2: Coin Vibrating Motor

Coin motor or 'pancake' motors use the same operating principle as pager motor (ERM); however, their eccentric mass is kept in their small circular body. Brushed coin vibration motors are constructed from a flat PCB on which the 3-pole commutation circuit is laid out around an internal shaft in the center. They are restricted in amplitude because of their size with extremely low profiles which make them popular in applications which space is restricted. Coin vibration motors have a relatively high start voltage which must be considered in designs. Typically, this is around 2.3v (all coin motors have a nominal voltage of 3v), and failure to respect this could result in coin motor not starting when the application is lying in certain orientations. This problem arises because in the vertical orientation, the coin motor must force the eccentric mass over the top of the shaft on the initial cycle.

### 3.2.2 Others

- Wires

Element that allows closing an electrical circuit. It has to be combined with soldering.

- Female-to-female

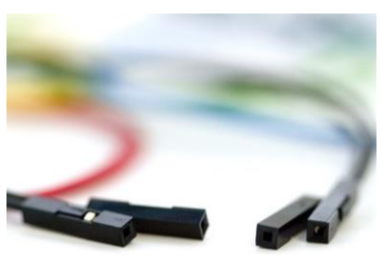

Figure 3.3: Female-to-female jumper wires

- Male-to-male

Figure 3.4: Male-to-male jumper wires

➢ 9 V Battery Holder with DC Jack

- For power supply to Arduino Board

Figure 3.5: 9 V Battery Holder with DC Jack

➢ Clothing material

- Parachute cloth for wrist band on which coin-vibrating motors have been connected interfaced to Arduino board

Figure 3.6: Parachute cloth

- Velcro to attach two different ends of the wrist band

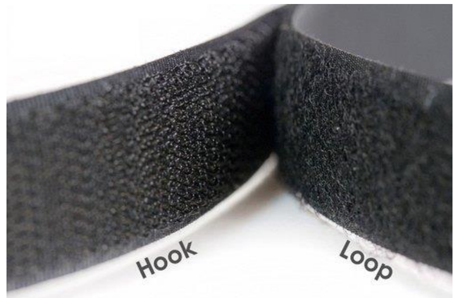

Figure 3.7: Velcro to tie up the wrist band

## 3.3 COMMUNICATION

We decided to use Bluetooth for the communication between Arduino and mobile application, more specifically HC-05 module.

This module is finally chosen to meet all application requirements. It is a wireless technology, the sender and the receiver are not physically connected, but through electromagnetic waves. It has a range of 10 meters, enough to be able to control the variables using mobile phone. Finally, the only additional requirement to make the communication between both devices is that the mobile phone has Bluetooth connectivity, which nowadays is a standard characteristic of mobiles.

Main characteristics:

- ✓ Configurable as Slave and as Master.
- ✓ Radio chip: CSR BC417143.
- ✓ Frequency: 2.4 GHz ISM band.
- ✓ Modulation: GFSK (Gaussian Frequency Shift Keying).
- ✓ Built-in PCB antenna.
- ✓ Emission Power: ≤ 4 dBm (Class 2).
- ✓ Range: 10 m.
- ✓ Speed: Asynchronous: 2.1 Mbps/160 kbps; Synchronous: 1 Mbps/1 Mbps.
- ✓ Security: Authentication and encryption.
- ✓ Profiles: Serial port Bluetooth.
- ✓ Current consumption: 50 mA.

- ✓ Supply voltage: 3.6 V – 6 V.
- ✓ Operation temperature: -20 ºC – 75 ºC.

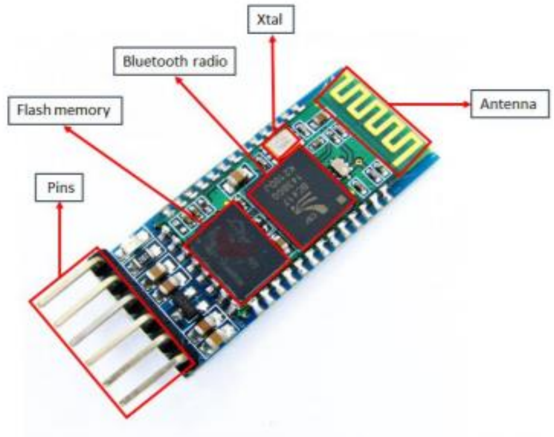


Figure 3.8: Bluetooth HC-05

## 3.4 MOBILE APPLICATION

### 3.4.1 Choice of Software

Nowadays thanks to the boom of mobile applications there are infinite possibilities to build one. One of them is to use a software in which is not needed to know anything of code, fact that facilities access to non-experienced users, but the problem of this option is that it greatly restricts the field of action in terms of functionality and default templates are often used, which also limits user's challenge of design own and unique mobile application. For these reasons, these types of software are discarded to be used during this project.

After this first selection, there are many software valid for the purpose of this project. The application was started to develop using Android Studio, but the lack of experience programming with Java turned the activity more difficult as the development of the application progressed.

Then it was decided that the best way to continue with the design and development was to use MIT App Inventor software, an integrated development environment to create mobile applications for Android operating system. The application's block editor uses the open blocks Java library to create a more intuitive language. The compiler that translates visual block language to Android uses Kawa as a programming language. Its resulting applications allows to cover a great number of basic needs in a mobile device, including all the requirements for the project application, but may be limited for other applications with more complexity.

Figure 3.9: Software for designing the app

### 3.4.2 Functionality of the Application

Mobile application is programmed to connect to a Bluetooth device to be able to send orders to Arduino board. Once it is connected, user has to give the input in the password text box. The password will be sent to Arduino board and will give output accordingly.

If not connected, then user will get an error message accordingly. Also, the user can disconnect the Bluetooth connected device anytime and can see the available devices. If user denies to send the password when entered or not, there will be a pop-up alert message to return to home page.

The .apk app has been named as "The_Vband" with a customized icon.

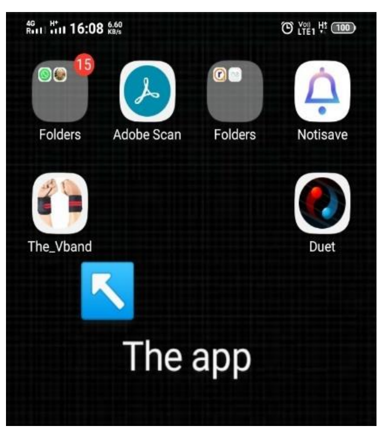


Figure 3.10: "The_Vband" app

CHAPTER 4

# HARDWARE AND PROGRAMMING

## 4.1 HARDWARE

### 4.1.1 Block Diagram

Below is the block diagram of the entire application:

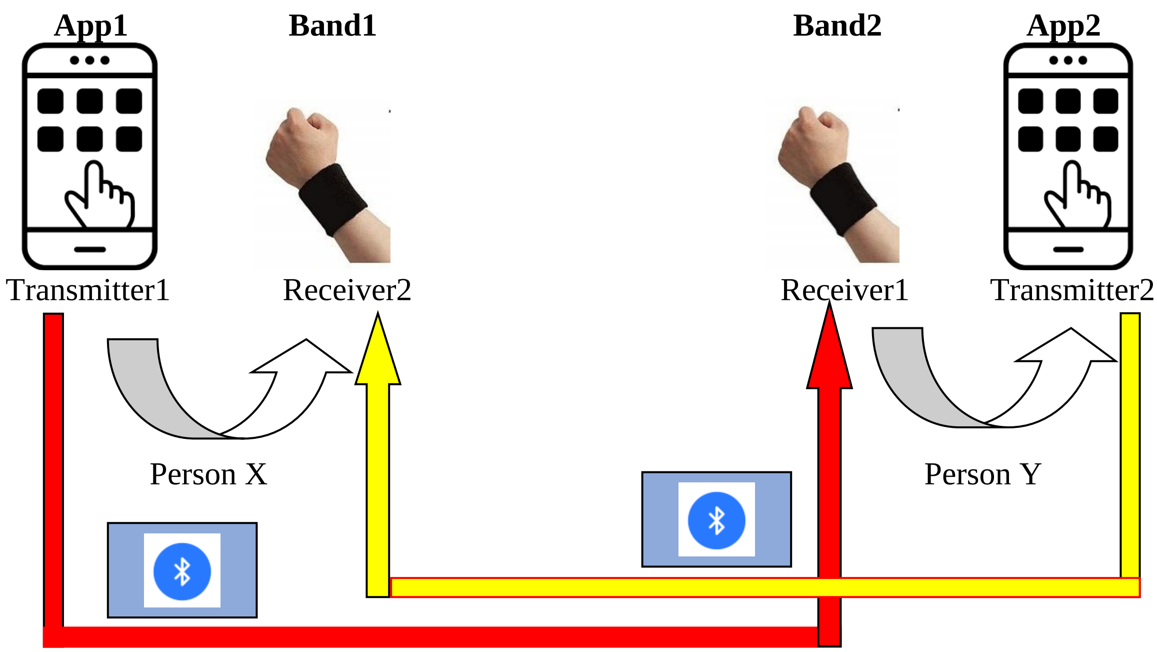


Figure 4.1: Block Diagram of working of “The_Vband”

The core of the application, where all the information is centralized, is the microcontroller ATmega328 included in the Arduino Mega board. The code is continuously executed in it and it collects all function modes, receiving orders of the mobile application, information of the environment through vibrators.

→ Transmitter1 will connect his android application to Receiver1 via Bluetooth who will be wearing the Band2 and thus will be able to send the short message.

→ Transmitter2 will connect his android application to Receiver2 via Bluetooth who will be wearing the Band1 and thus will be able to send the short message.

→ In this way, Person X and Person Y would be able to communicate with each other.

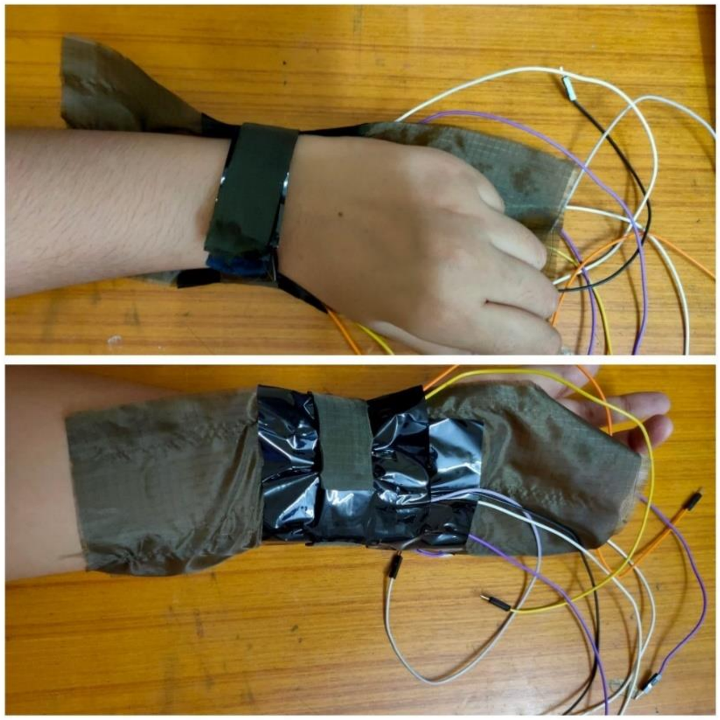

Figure 4.2: “The_Vband” prototype (without connections)

### 4.1.2 Connections

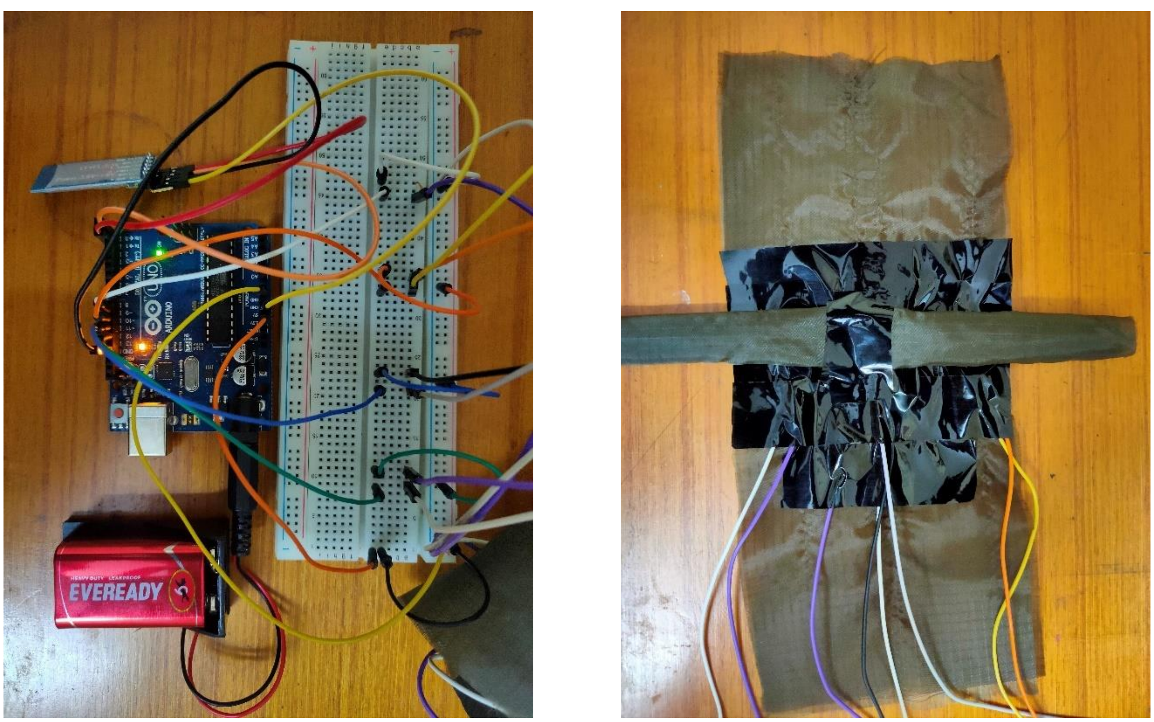


Figure 4.3: Connections of “The_Vband

Here are the connections which we did:

- Soldering has to be done for connecting the vibrating motors to cloth of wrist band
- The ‘3.3V’ pin (for vibrating motors) of the UNO board is connected to the positive rail of the breadboard.
- The ‘GND’ pin of the UNO board is connected to the negative rail of the breadboard.
- The coin-vibrating motor has two wires i.e., red and blue, the red wire is connected to the negative rail of the breadboard whereas the blue wire is connected to the positive rail.
  - ✓ this has to be repeated for all the 4 vibrating motors
- HC-05 has 6 pins out of which we don’t need to connect the pins ‘STATE’ and ‘EN’
  - ✓ pin ‘RXD’ has to be connected to ‘TX’ pin of Arduino and pin ‘TXD’ has to be connected to ‘RX’ pin of Arduino as we want our wrist band to be in a receiver state for now
  - ✓ pin ‘GND’ has to be connected to ‘GND’ pin of Arduino
  - ✓ pin ‘VCC’ has to be connected to ‘5V’ pin of Arduino

The 4 vibrating motors are arranged at $0^0$, $90^0$, $180^0$, $270^0$, or to say, North-East-West-South.

This arrangement was finalized as it will give the optimum output and the patterns that were to be assigned accordingly could easily be remembered by receiver when sent to the same.

The 4 vibrating motors i.e., $0^0$, $90^0$, $180^0$, $270^0$, are connected to digital pins 12, 11, 10, 9 respectively.

We decided that with the 4 vibrating motors, we can create a vibratory pattern based on hexadecimal number system (a/A-f/F and 0-9) and also it will be easy to remember.

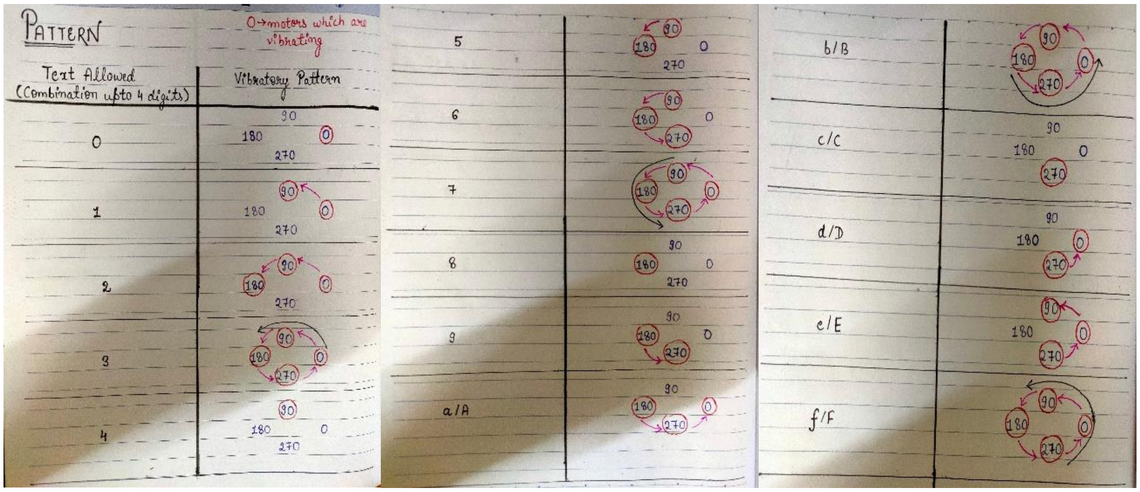

Figure 4.4: Vibration patterns for digits 0-9 and alphabets a/A-f/F

In the above figure, we have shown that which vibrating motors will vibrate when the particular assigned digit or alphabet will be sent by the transmitter to receiver.

As discussed earlier, the pattern is quite easy to remember; in the above figure, we can see that only 1 vibrating motor will vibrate for the digits, 0, 4, 8 and alphabet, C. For 3, 7, B, F, all the 4 vibrating motors will vibrate, which is also easy to remember.

## 4.2 PROGRAMMING

### 4.2.1 Arduino Programming

```
The_Vband
int Secret_Code;
String myStrings;

void setup()
{
    Serial.begin(9600);

    pinMode(12,OUTPUT);
    pinMode(11,OUTPUT);
    pinMode(10,OUTPUT);
    pinMode(9,OUTPUT);
}
```

Figure 4.5: Arduino Programming (Part-1)

We first declared our 2 variables i.e., Secret_Code and myStrings as integer and string datatypes respectively.

The setup() function is called when a sketch starts. The setup() function will only run once, after each powerup or reset of the Arduino board. In the setup() function we have declared pinMode() which will configure the specified pin to behave as output and as mentioned earlier that the vibrating motors, $0^0$, $90^0$, $180^0$, $270^0$, are connected to pin numbers 12, 11, 10, 9 respectively, that's why, pinMode (pin, Output). We also initialized Serial.begin (9600) to set the data rate in bits per second (baud) for serial data transmission as we have to connect HC-05 to Arduino Uno on TX/RX pins which are serial UART protocol in order to receive the data coming from mobile app to Arduino Uno.

```
The_Vband

void loop()
{

  Serial.println("Enter your Secret Code and make sure that it contains only digits(0-9) and alphabets(a/A-f/F) :");
  while(Serial.available() ==0) {  }
  while(Serial.available() > 0)

  {
    myStrings = Serial.readString();
  }

  Serial.println("Here you go!!!");
  for (int i = 0; i < 4; i++)
  {

    int value = myStrings[i]-48;
    if(value>9)


    {

      Secret_Code = myStrings[i];
      Serial.println(myStrings[i]);
```

Figure 4.6: Arduino Programming (Part-2)

In void loop() function, we will put our main code which has to be run repeatedly. The function Serial.println() prints data to the serial port as human-readable ASCII text followed by a carriage return character and a newline character. The function Serial.available() is used to get the number of bytes (characters) available for reading from the serial port, here '==0' will wait for the user to give input and '>0' will ensure that the user has entered the input and will go to next step. The function Serial.readString() reads incoming serial data. The for() loop here ensures that the user is entering the string consisting of $0^{th}$ to $3^{rd}$ index i.e., the user can enter a string such as 0a, f, abd, ab3e, 164d etc. Then, we have declared an integer variable, ‘value’, which will evaluate each character of the string which user gave as an input. As mentioned earlier, the user can input only hexadecimal digits, therefore, we subtracted the value by 48 because the ASCII value of 0 is 48. Then, we put up an if-condition for the variable value which ensures that all hexadecimal digits could be run.

For e.g., we entered a string “a9” or “A9”:

→ value = myStrings[i] – 48

→ ASCII value of a/A is 97, therefore, 97-48= 49 and being greater than 9, it will go to next step

→ASCII value of 9 is 57, therefore, 57-48=9 and which is true, therefore, it will go to next step

The_Vband

```
if(Secret_Code==97)
{
  Serial.println("Code a is running");
  digitalWrite(10,HIGH);
  delay(2000);
  digitalWrite(10,LOW);
  delay(2000);
  digitalWrite(9,HIGH);
  delay(2000);
  digitalWrite(9,LOW);
  delay(2000);
  digitalWrite(12,HIGH);
  delay(2000);
  digitalWrite(12,LOW);
  delay(2000);
}
if(Secret_Code==98)
{
  Serial.println("Code b is running");
  digitalWrite(10,HIGH);
  delay(2000);
  digitalWrite(10,LOW);
  delay(2000);
  digitalWrite(9,HIGH);
  delay(2000);
  digitalWrite(9,LOW);
  delay(2000);
  digitalWrite(12,HIGH);
  delay(2000);
  digitalWrite(12,LOW);
```

The_Vband

```
  digitalWrite(12,HIGH);
  delay(2000);
  digitalWrite(12,LOW);
  delay(2000);
  digitalWrite(11,HIGH);
  delay(2000);
  digitalWrite(11,LOW);
  delay(2000);
}
if(Secret_Code==102)
{
  Serial.println("Code f is running");
  digitalWrite(9,HIGH);
  delay(2000);
  digitalWrite(9,LOW);
  delay(2000);
  digitalWrite(12,HIGH);
  delay(2000);
  digitalWrite(12,LOW);
  delay(2000);
  digitalWrite(11,HIGH);
  delay(2000);
  digitalWrite(11,LOW);
  delay(2000);
  digitalWrite(10,HIGH);
  delay(2000);
  digitalWrite(10,LOW);
  delay(2000);
}
```

Figure 4.7: Arduino Programming (Part-3)

Then, we wrote the patterns for alphabets according to Figure 4.4 for a/A-f/F by declaring their ASCII values i.e., 97-102.

The_Vband

```
  }
  else
  {

  Secret_Code = value;
  Serial.println(Secret_Code);

  if(Secret_Code==0)
  {
     Serial.println("Code 0 is running");
     digitalWrite(12,HIGH);
     delay(2000);
     digitalWrite(12,LOW);
     delay(2000);
  }
  if(Secret_Code==1)
  {
     Serial.println("Code 1 is running");
     digitalWrite(12,HIGH);
     delay(2000);
     digitalWrite(12,LOW);
     delay(2000);
     digitalWrite(11,HIGH);
     delay(2000);
     digitalWrite(11,LOW);
     delay(2000);
  }
  if(Secret_Code==2)
  {
```

The_Vband

```
       digitalWrite(10,HIGH);
       delay(2000);
       digitalWrite(10,LOW);
       delay(2000);
    }
    if(Secret_Code==9)
    {
       Serial.println("Code 9 is running");
       digitalWrite(10,HIGH);
       delay(2000);
       digitalWrite(10,LOW);
       delay(2000);
       digitalWrite(9,HIGH);
       delay(2000);
       digitalWrite(9,LOW);
       delay(2000);
    }
    }

  digitalWrite(12,LOW);
  digitalWrite(11,LOW);
  digitalWrite(10,LOW);
  digitalWrite(9,LOW);
  Serial.println("exiting program");

  }

}
```

Figure 4.8: Arduino Programming (Part-4)

Then, we wrote the patterns for digits 0-9 according to Figure 4.4.

If the user enters a string which consists of alphabets other than a/A-f/F, then the program will be exited for that particular index.

### 4.2.2 Mobile Application Programming

As explained earlier in the previous section, we designed an app for our project on MIT App Inventor.

It is an intuitive, visual programming environment that allow the users to build fully functional apps for Android easily.

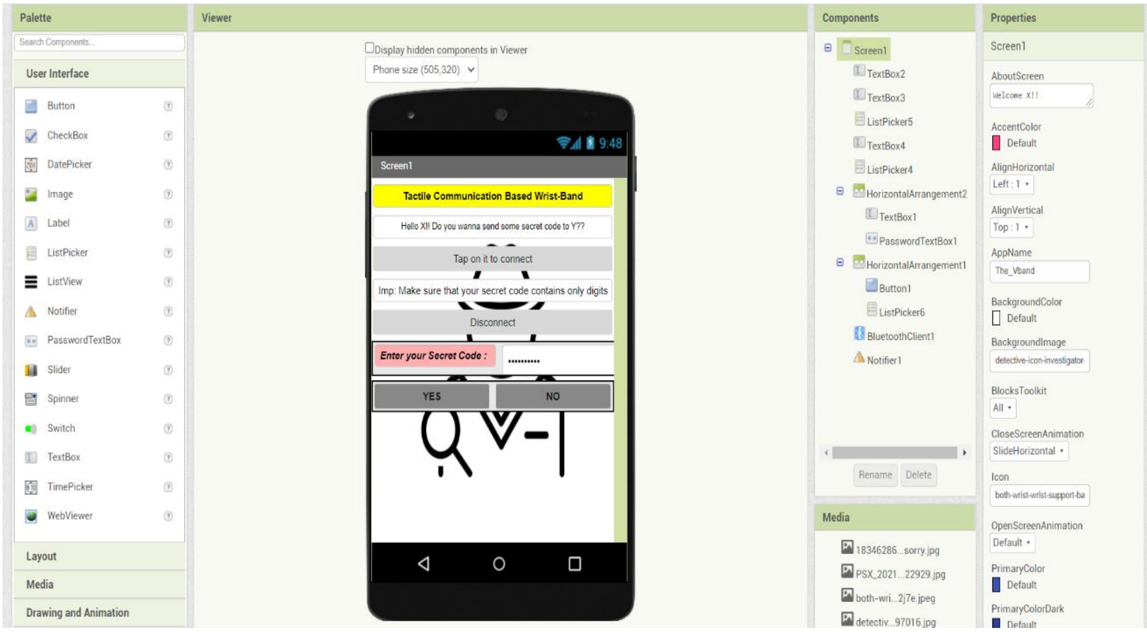


Figure 4.9: Screen Viewer on MIT App Inventor

Here, the Bluetooth client and Notifier1 will be hidden from the screen.

- ‘Screen1’ is the screen where our designed app will be shown to the user
- ‘Tactile Communication Based Wrist-band’ is “TextBox2”
- ‘Hello X!!’ line is “TextBox3”
- ‘Tap on it to connect’ is “ListPicker5”
- ‘Imp.’ line is “TextBox4”
- ‘Disconnect’ is “ListPicker4”
- ‘Enter your Secret Code:’ is “TextBox1”
- Password entering box is “PasswordTextBox1”
- ‘YES’ is the “Button1”
- ‘NO’ is the “ListPicker6”

Block-based programming has been done only for the ListPickers and Buttons.

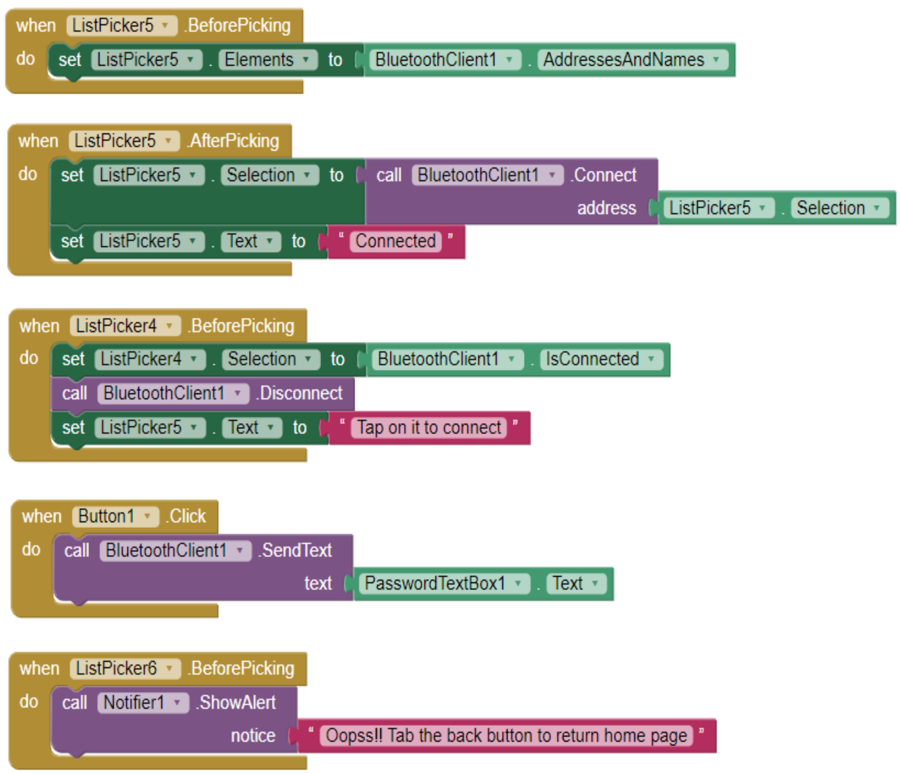


Figure 4.10: Block-based programming of app

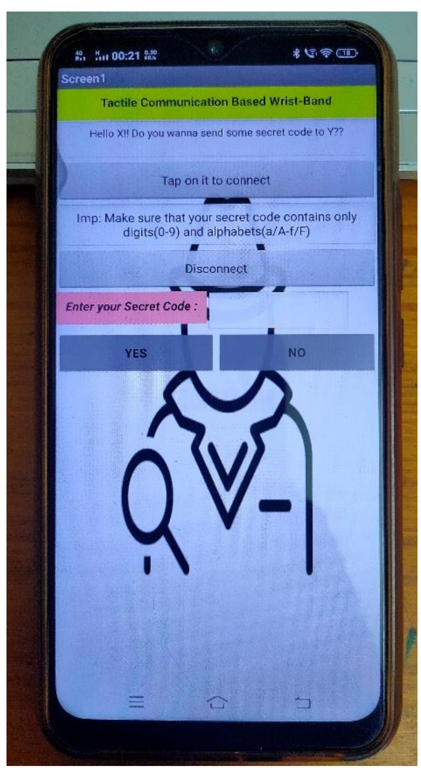


Figure 4.11: View of app screen on Android

When user taps on the app namely, “The_Vband”, a screen will be shown as in Figure 4.12. As our band is based on Bluetooth connectivity, the Bluetooth of the android should be turned on. Then, for sending the message, the android app and wrist-band should be connected and for that the user should tap on the ListPicker, namely, “Tap on it to connect” which will show the available devices. After connecting to HC-05 module, the list-picker will show a ‘Connected’ text ensuring the user for a successful connection. A text-box with a message is shown for user to enter the right string without wastage of time. The user can enter the string in the password text-box and after tapping on “Yes”, the string or input will be sent to the wrist band and thus will vibrate accordingly. The user can disconnect with HC-05 anytime, which in turn will alter the “Connected” text to “Tap on it to Connect” which will show the available devices when clicked on same.

If the user taps on “NO”, an alert notice will be shown to go back to home page.

CHAPTER 5

# CONCLUSION

The strength of the project lies in its use of integrated modalities of touch and text. This investigation into the mixed modality of texting-tactile interaction provides some insight on the use of the tactile channel. Touch communication was shown to enhance a texting conversation by providing redundant and independent information in the form of tactile gestures. This allows communication of nonverbal cues that can be lost or overlooked when only the texting channel is present. Within moments, people new to the device will be able to communicate through the tactile channel in a non-trivial and successful way. We hope that this kind of research will contribute to enhancing existing communications by adding the underused sense of touch. Understanding the nature of touch and its role in communication may eventually inform the development of a touch communication language.

The further work on the device will consist of making it continuous i.e., the ability to connect to communicate using analog signals which allows more variety in communication. Also, holding on to our earlier proposed objectives regarding the device's performance and attachment of all 12-14 vibrating motors with proper alignment, the device should be working on four different parameters namely, frequency, intensity, spatial distance between vibrators and duration of vibration.

# REFERENCES

*Journal Papers:*

[1] Galadima, A.A., "Arduino as a learning tool," in Electronics, Computer and Computation (ICECCO), 2014 11th International Conference on , vol., no., pp.1-4, Sept. 29 2014-Oct. 1 2014 doi: 10.1109/ICECCO.2014.6997577

[2] Badamasi, Y.A., "The working principle of an Arduino," in Electronics, Computer and Computation (ICECCO), 2014 11th International Conference on , vol., no., pp.1-4, Sept. 29 2014-Oct. 1 2014 doi: 10.1109/ICECCO.2014.6997578