IMPLEMENTING A VIRTUAL GUITAR USING 3-AXIS ACCELEROMETER

A PROJECT REPORT

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ELECTRONICS AND COMMUNICATION

2014-15

CERTIFICATE

Date: 05/2015

This is to certify that the dissertation entitled **“IMPLEMENTING A VIRTUAL GUITAR USING 3-AXIS ACCELEROMETER”** has been carried out by **Vatsal H. Salla & Mihir N. Malaviya** and under my guidance in fulfilment of the degree of Bachelor of Engineering in Electronics and Communication (4^{th} year of BE) of Gujarat Technological University, Ahmedabad during the academic year 2014-15**.**

Mentor	**Head of department**
Mr. Kaushal J. Doshi **(Assistant Professor)**	**Dr.Rajendra Patel** **(Associate Professor)**

ACKNOWLEDGEMENT

It gives us immense pleasure and satisfaction in submitting this paper report on **IMPLEMENTING A VIRTUAL GUITAR USING ULTRASONIC SENSOR.** In the endeavor of preparing this paper report many people gave us a helping hand. On the outset of this report, we would like to express our sincere gratitude to our project guide **MR. KAUSHAL J. DOSHI** for his guidance, input and support throughout this process.

Furthermore, we would also like to acknowledge the crucial role of the staff of Electronics and Communication Department, who gave permission to use all required equipment(s) and the necessary tool(s). We would also like to appreciate the guidance given by other supervisors especially in our project presentation which helped us in improvement of our presentation skills; thanks to their comment and advices. Special thanks to **DR. RAJENDRA PATEL** and **PROF. ANURAG P LAKHLANI** invaluable participation in our project.

ABSTRACT

This is a concept by which a conventional guitar is virtualized through the knowledge of Electronics and Communication. Our aim is to bring advancement in the field of music by taking the guitar on virtual platform.

By using the principle of accelerometer, we have tried to select the corresponding levels and played the respective sound(s) for the respective position(s) or swing of the plectrum as per the stored wave file. The microcontroller is programmed to play the stored sound(s) which eliminates soundboard of the conventional guitar and takes it to the virtual level.

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Chapter 1 Introduction

1.1 General

Guitar is one of the renounced musical instruments worldwide. It is a multifunctional instrument which produces tunes, bass, treble etc. By this concept, we have made an honest effort in order to make this instrument virtual rather invisible and have successfully removed certain problems which one might face in a conventional guitar by taking it on a virtual platform.

1.1 Project Motivation

The idea was to bring an advancement in the field of music. Guitar is comparatively a better-known instrument. Having a knowledge of the actual guitar had already built the foundation and made it easier to deal with this project. The literature review started with visiting the *Cowboy Guitars*, one of the finest music centers in the city. The aim in visiting was to learn the problems faced by a guitarist in the journey of guitar learning. Learning at different ages made a difference too. The visit gave ideas to look for possible ways to solve those problems. We discussed all the problems from different aspects of electrical engineering. We were able to figure out the actual difference between an acoustic, acoustic electric and the electric guitar at the manufacturing level.

A discussion with the music professional Mr. Baba made us clear about the problem. With this we tried to figure out the problems with the guitar. As discussed above we came up with problems like handling of guitar, tuning, breaking of strings and many such problems. We tried to materialize all the aspects in the electronics domain.

Idealistic solution:

Problems like breaking of strings can be resolved by using a senor instead of an actual string. Ultrasonic sensors work on the principle of measuring distance with the sound waves emittance, reflection and detection. This principle of ultrasonic sensor was used in generating the frequency which is the concept on which the conventional guitars work. This frequency was used in generating the corresponding sound. Sound was amplified with the help of a loudspeaker and thus was able to virtualize the guitar.

1.2 Aim

To play the strings of the guitar and generate the tunes by making no physical contacts thus making the guitar, virtual.

1.3 Requirements

There is as such no requirement for this project at viewing the current scenario but if this prototype is developed at the industrial level, it might be able to bring a solution to the problems which were never thought as problems before. It will bring a revolution in the musical instruments in future. This is a decade of IOT and Embedded Systems and this project will be able to able to prove its requirement very soon. Manufacturing the guitar at the virtual level will surely help in modernization. Moreover, the conventional guitar has certain problems which are unknown and irrelevant to guitarists as per their knowledge till date. This concept will help in solving all these problems.

A guitar is a slightly heavy instrument. An acoustic guitar is made of different types of wood, electric and base guitars are made up of fiber, plastic or even metals. They all consist of a number of strings for producing the respective notes as per the strings which are plucked. These guitars are available in market starting from approximately 2k up to 10s of lakhs in INR. The perception of an electrical engineer towards a guitar is different as compared to a guitarist. So, we have come across some problems in reference to the conventional guitar which can be described as follows:

Handling Problems:

A normal guitar size is 38 inches (beginner) which can be up to 41 inches for a dreadnought guitar. Maintaining a guitar in a small space can be difficult and tricky thus. Thus, a guitar can be characterized as While travelling with the guitar, due to its bulkiness and its delicateness we need to have a wooden case which is very costly. So due to this the beginners generally face the problems of aching of fingers and slight swelling in shoulder.

Figure No. 1.4.1: Handling problem [1]

Tuning:

The melodious sound of guitar depends on the strings of guitar i.e. tuning. Improper tuning or a detuned guitar results in noise. There are many ways to fix this. There are tuners available in the market, apps available in the play store & app store and other handy tools which are available on Amazon, Ebay and other online websites. Detuning in guitar can be because of adding a capo, improper placement, accidental movement of screw(s) and if it is not used for a long time.

Figure No. 1.4.2: Tuning [2]

Breaking of strings:

Sound in a guitar is produced by the strings vibrating at respective frequencies. The condition of strings defines the condition of guitar. Breaking of strings depends on the usage of guitar. Wear and tear occurs approximately twice a year depending upon the usage. Cost of new strings is moderate to expensive depending upon the type of guitar. The strings of guitar can also break if not tuned from time to time.

Figure No. 1.4.3: Breaking of strings [3]

2.1 Brief literature review of patents

Patent 1: US 5432755 A

Ultrasonic signal detector

The given patent displays the generation of frequency with the help of sound waves which is generated by the device given below. The device sends out a sound wave of a particular frequency for which the signal after collision with the target reflects back and is recorded to generate frequency.

Publication number	US5432755 A
Publication type	Grant
Application number	US 08/208,536
Publication date	Jul 11, 1995
Filing date	Mar 8, 1994
Priority date	Mar 8, 1994
Fee status	Paid
Inventors	Nikolaos I. Komninos
Original Assignee	Komninos; Nikolaos I.
Export Citation	BiBTeX, EndNote, RefMan

Figure No. 1.5.1: Patent one description [4]

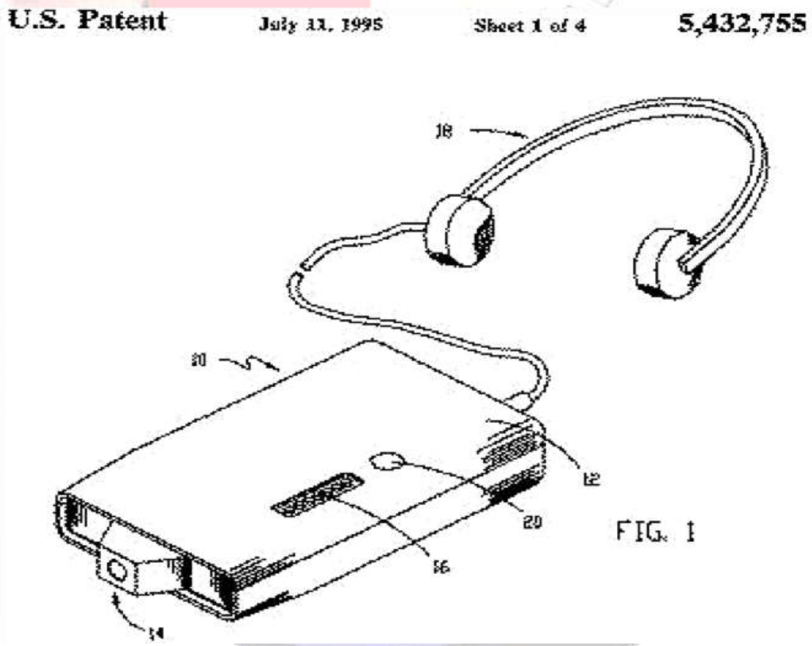


Figure No. 1.5.2: Patent one data [5]

Patent 2: US 5541358 A

Patent Position-based controller for electronic musical instrument

The patent given below deals with the generation of frequency for w.r.t. the position of the obstacle in three dimensions. The generated frequency is then used to drive the musical instrument; for instance, a guitar.

Publication number	US5541358 A
Publication type	Grant
Application number	US 08/037,924
Publication date	Jul 30, 1996
Filing date	Mar 26, 1993
Priority date	Mar 26, 1993
Fee status	Paid
Inventors	James A. Wheaton, Erling Wold, Andrew J. Sutter
Original Assignee	Yamaha Corporation
Export Citation	BiBTeX, EndNote, RefMan

Patent Citations (8), Non-Patent Citations (6), Referenced by (25), Classifications (8), Legal Events (4)

Figure No. 1.5.3: Patent two description [6]

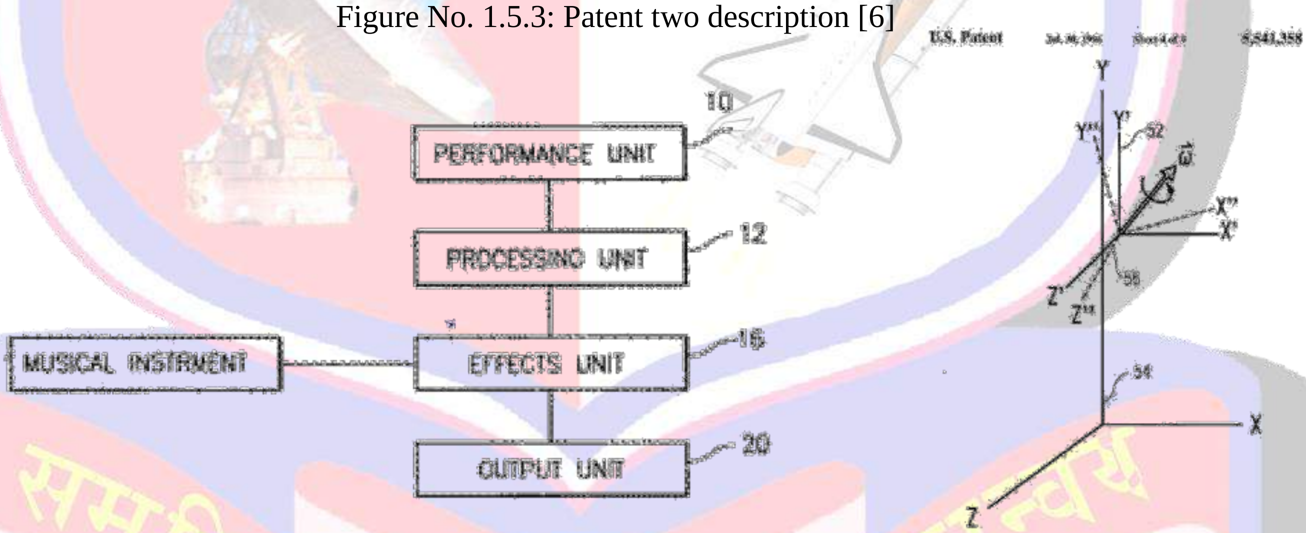


FIG. 2

Figure No. 1.5.4: Patent two data [7]

Patent 3: US 5393926 A

Virtual music system

The below given patent is in reference to the generation of music but in this we deal with the stored notes which are played up for a given specification of the device. The notes are stored and automatically played by the user

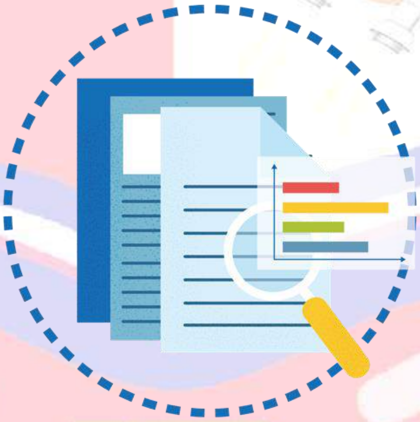
Publication number	US5393926 A
Publication type	Grant
Application number	US 08/073,128
Publication date	Feb 28, 1995
Filing date	Jun 7, 1993
Priority date	Jun 7, 1993
Fee status	Paid
Also published as	CA2164602A1, 6 More »
Inventors	Charles L. Johnson
Original Assignee	Ahead, Inc.
Export Citation	BiBTeX, EndNote, RefMan

Figure No. 1.5.5: Patent three description [8]

Chapter 2 Design methodology and problems identification

2.1 Identification of project

Solution of the mentioned problems can be solved up to some extent by our concept i.e. VIRTUAL GUITAR. Since our Guitar is a virtual concept so it removes all the problems faced in conventional guitar. We expect our conceptual guitar to help us in the removal of handling problems since size will be drastically reduced since here we are materializing the whole guitar in the form of sound waves and also since we are not using any kind of bulky wooden case so there will be no problem of carrying it. Tuning will be predefined in the form pre-set frequencies so there is no question of guitar being detuned. Since we are not using strings and the work of strings will be carried out by the sound waves so there will be no problem arising due to strings and costing of this guitar will be comparatively less than the conventional guitar. In a nutshell, an effort has been made to eliminate the problems faced in conventional guitar and also trying to make something which will bring some advancement in technology in the field of music.



2.2 Canvas

a) **Observation Matrix**

When defining the project scope, the team explores the immediate project activities, Milestones and end results. They are placed either inside or outside of the project's scope. The elements should be revised until a satisfactory scope has been created. To make the best use of scope as a project guideline, all stakeholders should commonly agree upon and authorize the defined scope before initiating the project. All these activities and their summary were jotted down by all the students in their canvas using sticky notes. They had funnelled out a single scope and limitation that will be overcome by their projects. This canvas formed the base of their project and directed their work flow.

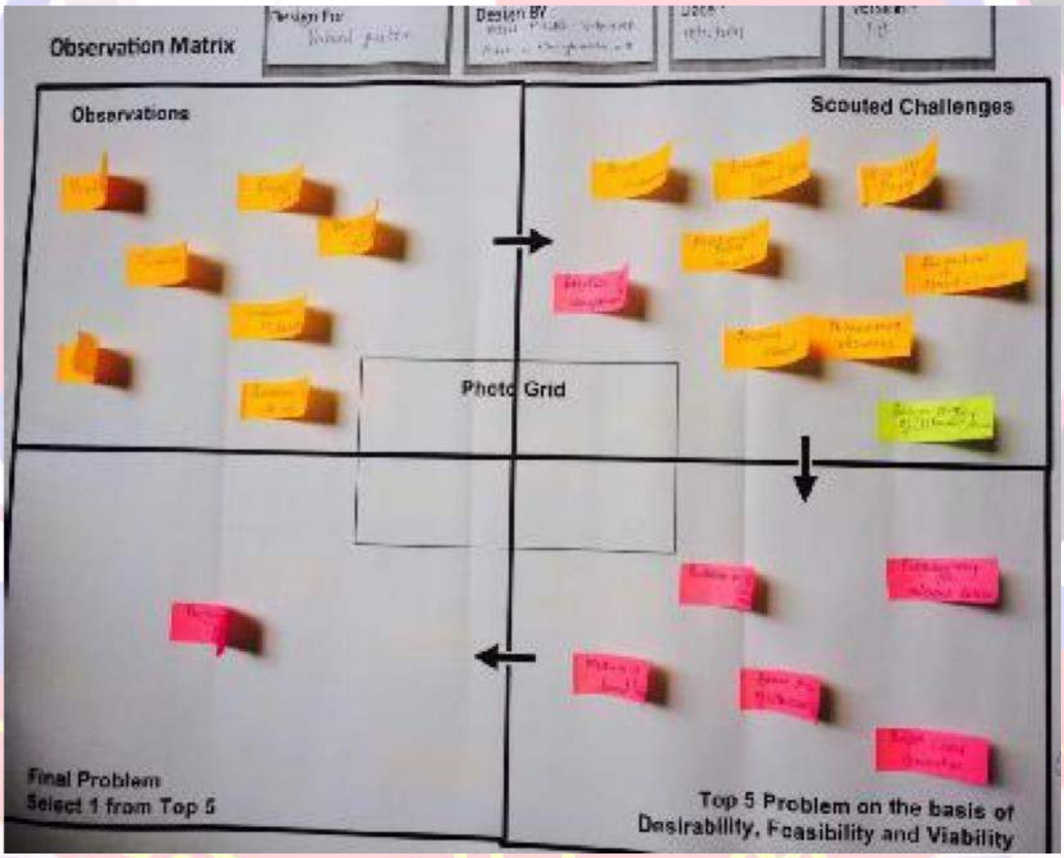


Figure No. 2.2(a): Observation Matrix

b) Ideation Canvas

Decision points: For selecting sets of actions and transition to a new phase, coordination points where worked on several fields must be completed at a certain point in time with questions like, 1. What is the best way to describe the necessary actions? 2. Does each action have a direct link to one or more of the outcomes? 3. Are the actions detailed enough to develop a project plan? All these questions were answered by various teams in their ideation canvas in props/possible solutions.

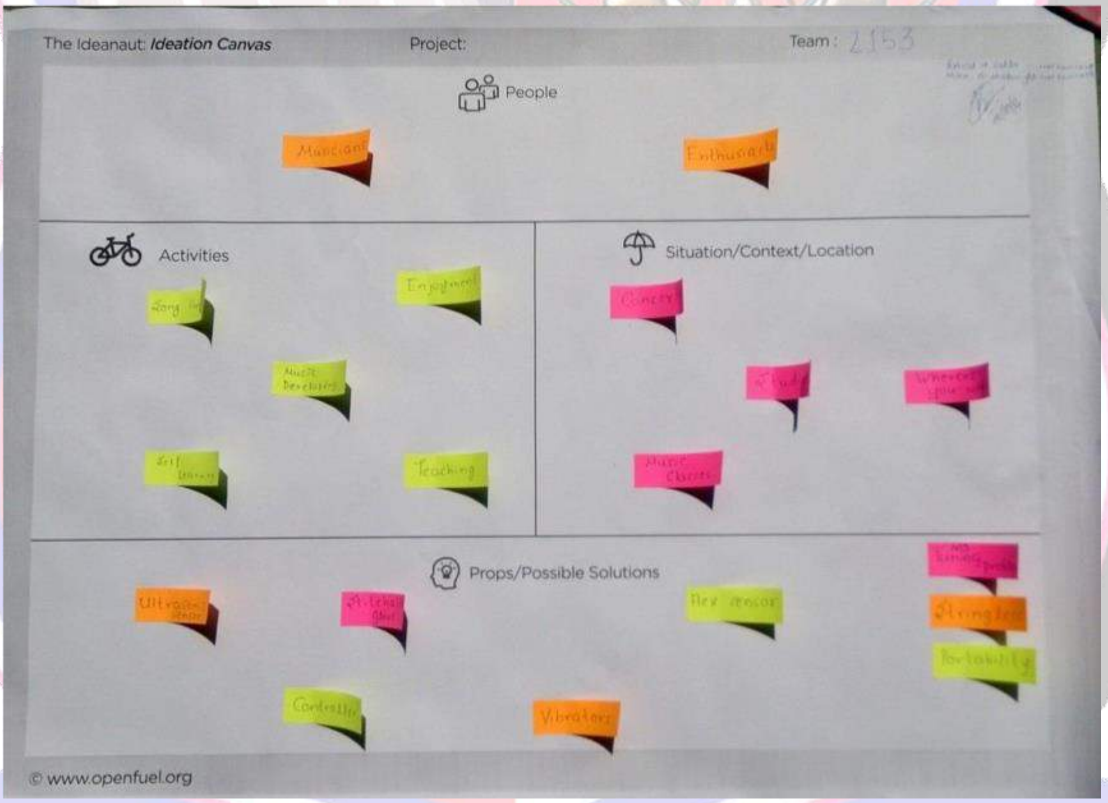


Figure No. 2.2(b): Ideation Canvas

c) Idea Funnel Canvas

Design Thinking is a methodology used by designers to solve complex problems and find desirable solutions for clients. Design Thinking draws upon logic, imagination, intuition, and systemic reasoning, to explore possibilities of what could be, and to create desired outcomes that benefit the end user. It involves both analysis and imagination. Design is the action of bringing something new and desired into existence a proactive stance that resolves or dissolves problematic situations by design. It is a compound of routine, adaptive and design expertise brought to bear on complex dynamic situations.

Figure No. 2.2(c): Idea Funnel Canvas

d) Business Model Canvas Report

The Business Model Canvas for Virtual Guitar is designed. The following content gives explanation related to the same for various fields in BMC.

1. **<u>Value Propositions:</u>** This field should contain the data related to the value delivered to customers or in other words what different things are provided to the customer in the product. Various values for this system are as below.

- Stringless
- No tuning required
- No heavy physical entity
- Tunes can be heard via earphones

2. **<u>Customer Segment:</u>** As the name suggests, the field contains the target customer for whom the system is designed. List of various customer segments are as below.

- Music companies
- Music enthusiasts
- Guitar tutors

3. **<u>Customer Relationships:</u>** The type of relationships customer expects from the system and the business party is the main focus in this section. Various types of relationship needed for selling the product successfully to survive in business world can be as below.

- Friendly
- Professional

4. **<u>Channel:</u>** This segment should contain the channels available to reach and inform the customers about the product. Followings are some of the channels to the customer segment.

- Publicity via Internet
- Advertisements
- Practical demonstration

5. **Key Partners:** The key partners for running business successfully should be considered here. For such electronic system, some of the partners may be as below.

- Guitarists
- E-commerce

6. **Key Activities:** Various key activities are listed in this section of BMC to run the business. It contains some activities related to product manufacturing and others for servicing and maintenance.

- Play tunes

7. **Key resources:** Major resources needed for such purpose are to be categorized in this section. To perform some of the activities listed above, these resources are needed.

- Electronic components
- Manpower
- Finance

8. **Cost Structure:** The cost structure for the business model is as below

- Material cost

9. **Revenue Streams:** The business generates revenue from following ways.

- Door to door selling
- E - commerce

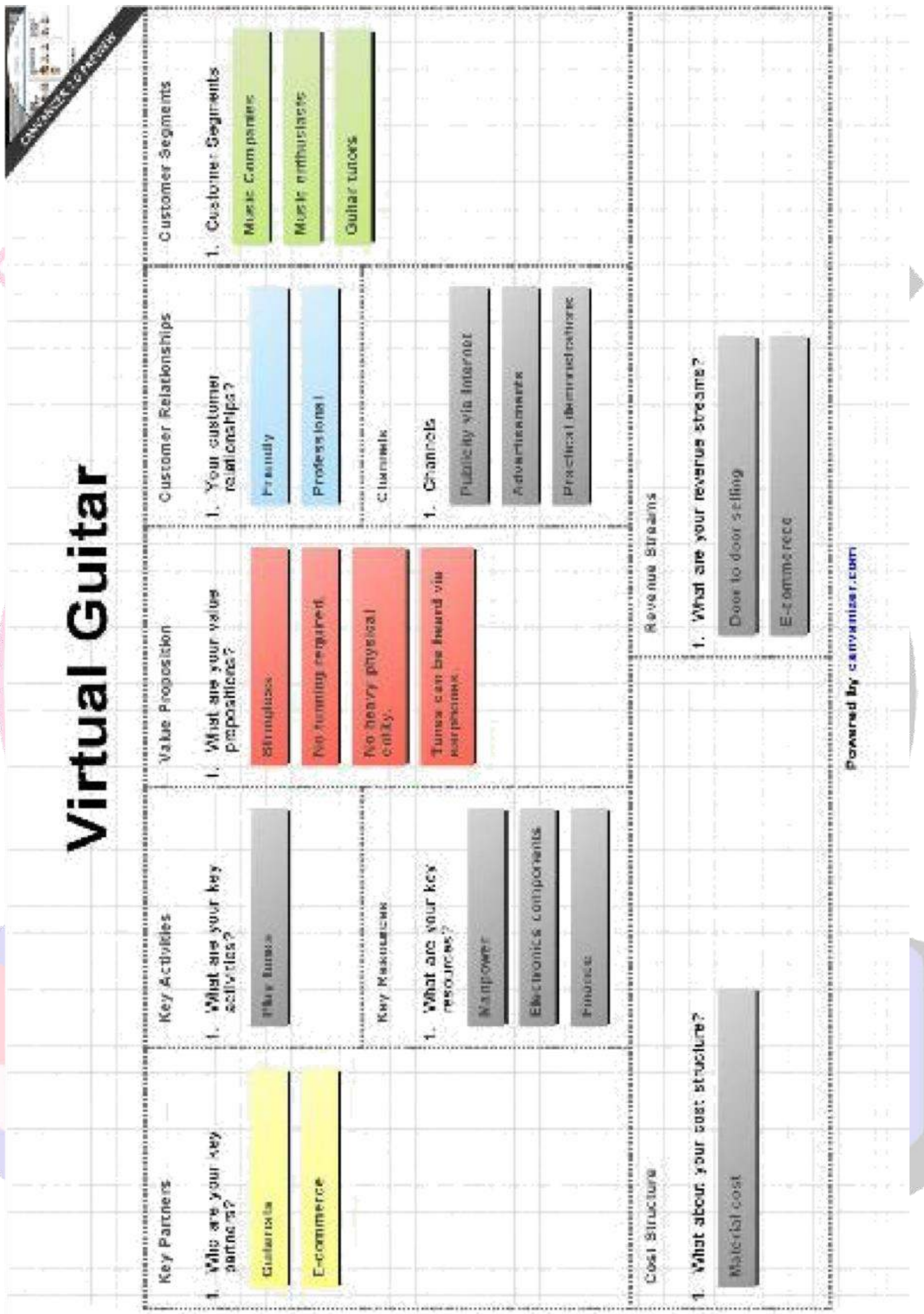


Figure No. 2.2(d): BMC Report [9]

Chapter 3 Initial project assumptions and constraints

Block Diagram

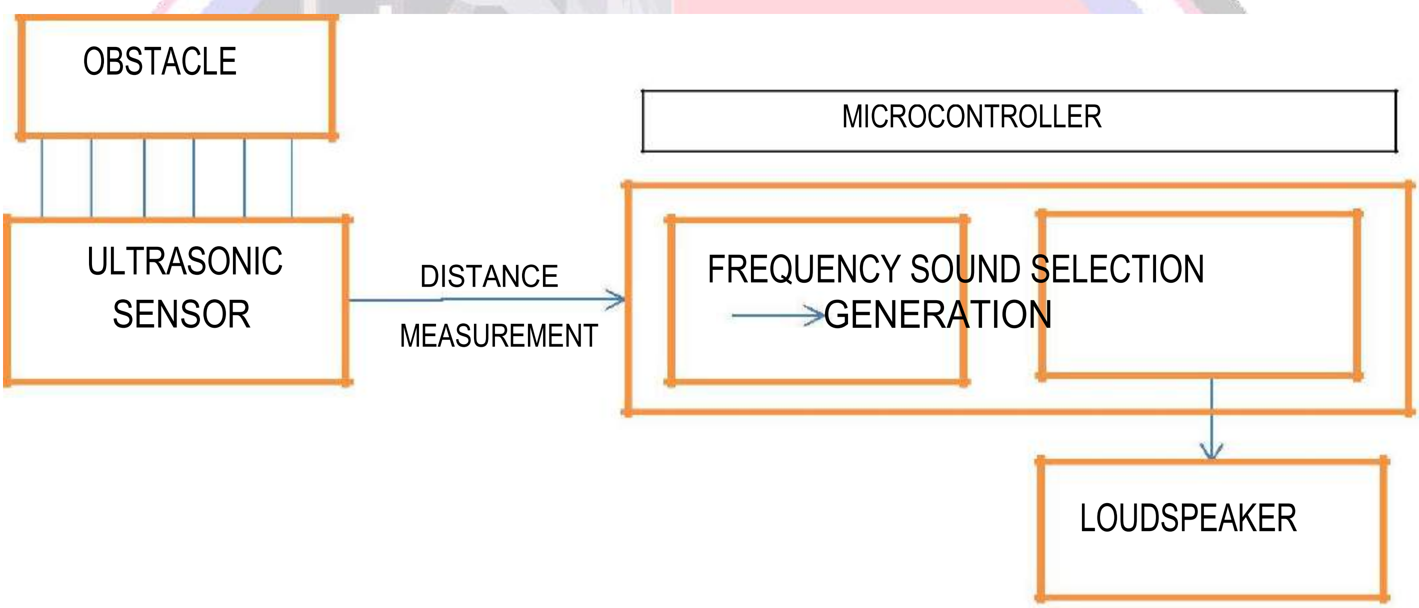


Figure 3.1 Initial Block Diagram

3.3 Literature survey

3.1.1 Sensors (distance measurement):

- Infrared sensors
- Ultrasonic sensors
- Accelerometer

3.1.2 Development boards familiar (as per requirement)

- Arduino UNO
- Arduino LilyPad
- Raspberry Pi 1.0
- Raspberry Pi 2.0

Table 3.1 Comparison of sensors

Infrared sensors	Ultrasonic sensors
They depend on external entities	Such problems are not faced
Depends on surface	Surface dependence is not a big problem
Less accurate	More accurate
Sunlight can affect the operate	Works in any light
Narrow beam width	Wide beam width
Low cost	High cost
No Echo problem	Echo problem

From the properties and problems discussed in both the sensors in the Table 3.1.2, we came up with a conclusion that ultrasonic sensor having the negligible disadvantages as per our requirements should be preferred over infrared sensor.

Ultrasonic sensor: **HC – SR04**.

3.3 Ultrasonic sensor HC SR – 04

The HC-SR04 ultrasonic sensor uses sonar to determine distance to an object like bats or dolphins do. It offers excellent non-contact range detection with high accuracy and stable readings in an easy-to-use package. From 2cm to 400 cm or
1‖ to 13 feet. It operation is not affected by sunlight or black material like Sharp rangefinders are (although acoustically soft materials like cloth can be difficult to detect). It comes complete with ultrasonic transmitter and receiver module.

Features

- Power Supply: +5V DC
- Quiescent Current: <2mA
- Working Current: 15mA
- Effectual Angle: <15°
- Ranging Distance: 2cm – 400 cm/1" - 13ft
- Resolution: 0.3 cm
- Measuring Angle: 30 degrees
- Trigger Input Pulse width: 10uS
- Dimension: 45mm x 20mm x 15mm

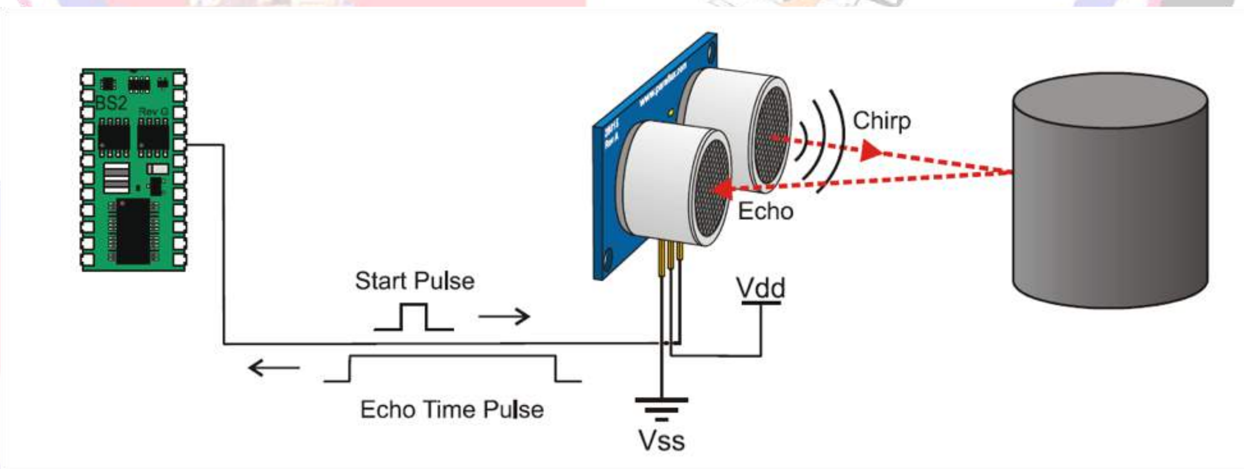


Figure 3.2.1: Ultrasonic sensor [10]

3.4 Types of pins of Ultrasonic sensor

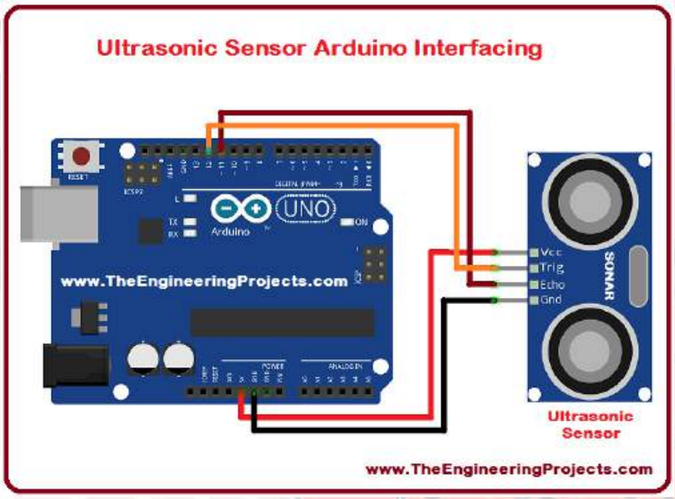


Figure 3.2.2: Different views of ultrasonic sensor [11]

3.5.1 VCC = +5V DC

For generation of sound waves from the ultrasonic sensor we need to give
+5v dc supply in this pin.

3.5.2 Triggering Pin = Trigger input of Sensor

This pin is nothing but a triggering pulse generation pin. When the pin is high i.e. triggering pulse is achieved in this pin then and only then ultrasonic sensor will start generating the sound waves.

3.5.3 Echo pin = Echo output of Sensor

This pin is a receiver pin. Since this sensor is a transceiver it also can receive the signals. Now when the sound waves will encounter obstacle then the echoed signals will be transmitted back to the sensor which will be received by this particular pin.

3.5.4 Gnd = Ground Pin

The principle of ultrasonic distance measurement uses the known air spreading velocity, measuring the time from launch to reflection when it encountered obstacle and then calculate the distance between the transmitter and the obstacle. Thus, the principle of ultrasonic sensor is same as radar.

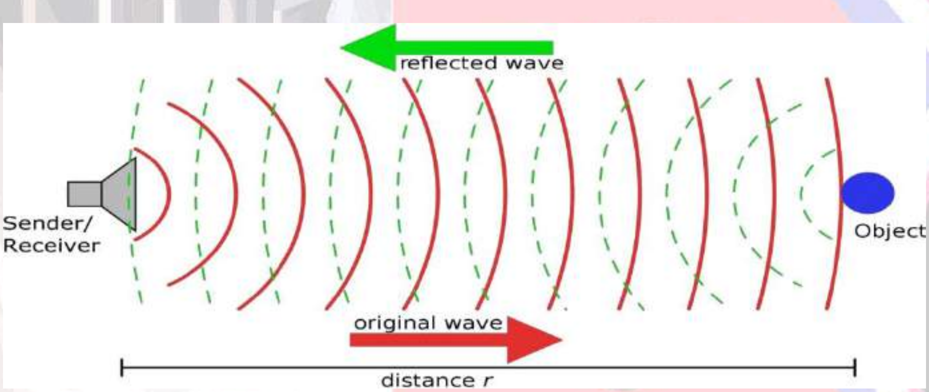


Figure 3.2.3: Ultrasonic principle [12]

3.3 Beam width

The accuracy of the project depends on the beam width of ultrasonic sensors. The number of ultrasonic sensors equals the number of strings of the guitar. Currently we plan to go for an acoustic guitar. Further modifications shall be made as per the probable conditions. Beam width is the span of area in which the sound waves of ultrasonic sensor or in one word the coverage of the sensor. Given figure below displays the beam width of ultrasonic sensor

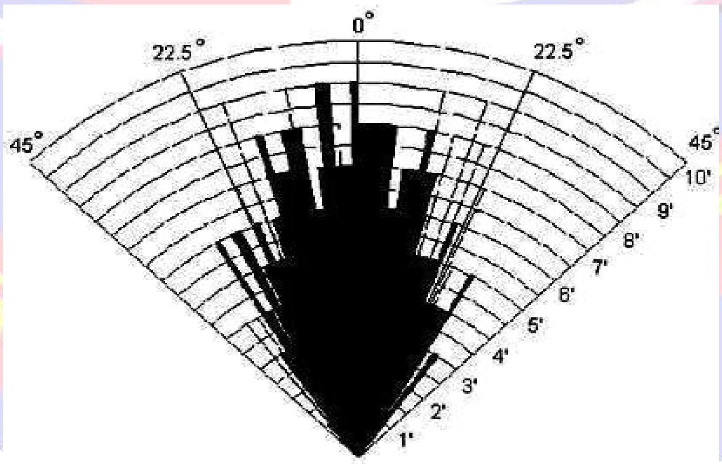


Figure 3.3.1: Beam width [13]

3.4 Product specification and limitations

Table 3.4 Product Specifications

Parameters	Min	Typ.	Max	Unit
Operating Voltage	4.50	5.0	5.5	V
Quiescent Current	1.5	2	2.5	mA
Working Current	10	15	20	mA
Ultrasonic Frequency	-	40	-	kHz

From the above specifications various characteristics of Ultrasonic sensor can be known.

3.5 Operation

The timing diagram of HC-SR04 is shown. To start measurement, Trig of SR04 must receive a pulse of high (5V) for at least 10us, this will initiate the sensor will transmit out 8 cycle of ultrasonic burst at 40kHz and wait for the reflected ultrasonic burst. When the sensor detected ultrasonic from receiver, it will set the Echo pin to high (5V) and delay for a period (width) which proportion to distance. To obtain the distance, measure the width (Ton) of Echo pin.

Time = Width of Echo pulse, in micro seconds

3.5.1 Distance in centimetres = Time / 58

3.5.2 Distance in inches = Time / 148

3.5.3 Speed of sound can be utilized = 340m/s

3.5.1 Duty Cycle of Ultrasonic Sensor

The GND pin has to be connected first before supplying power to VCC. The surface of object to be detected should have at least 0.5 $meter^2$ for better performance.

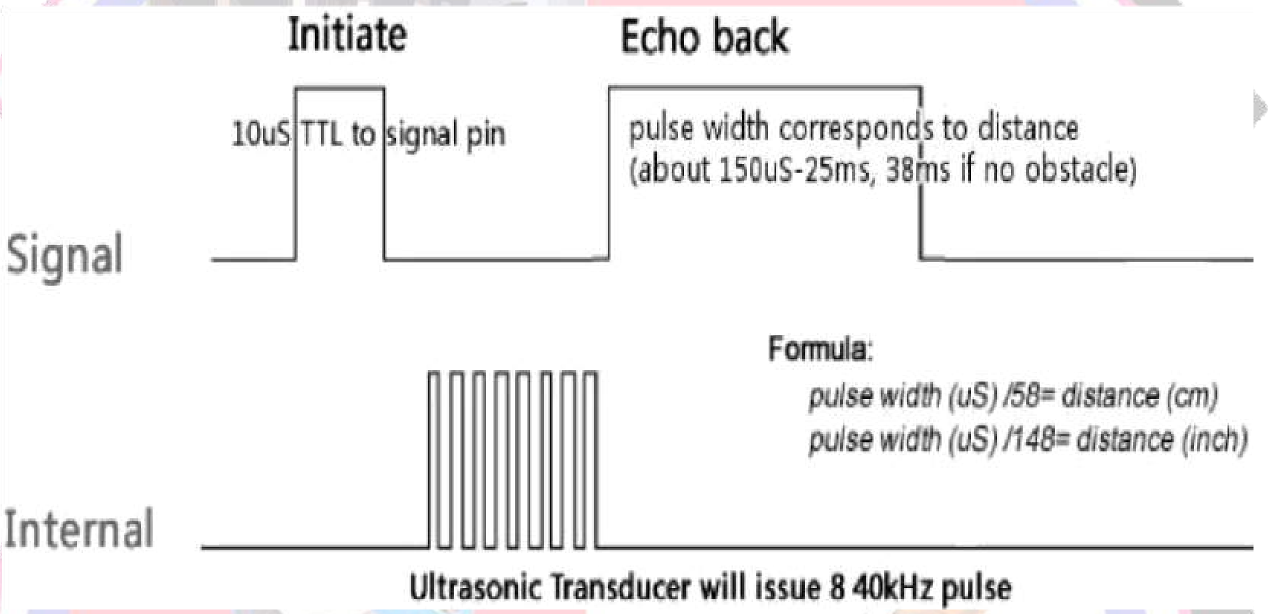


Figure 3.5: Duty cycle of sensor [14]

3.6 Development Board – ARDUINO LilyPad

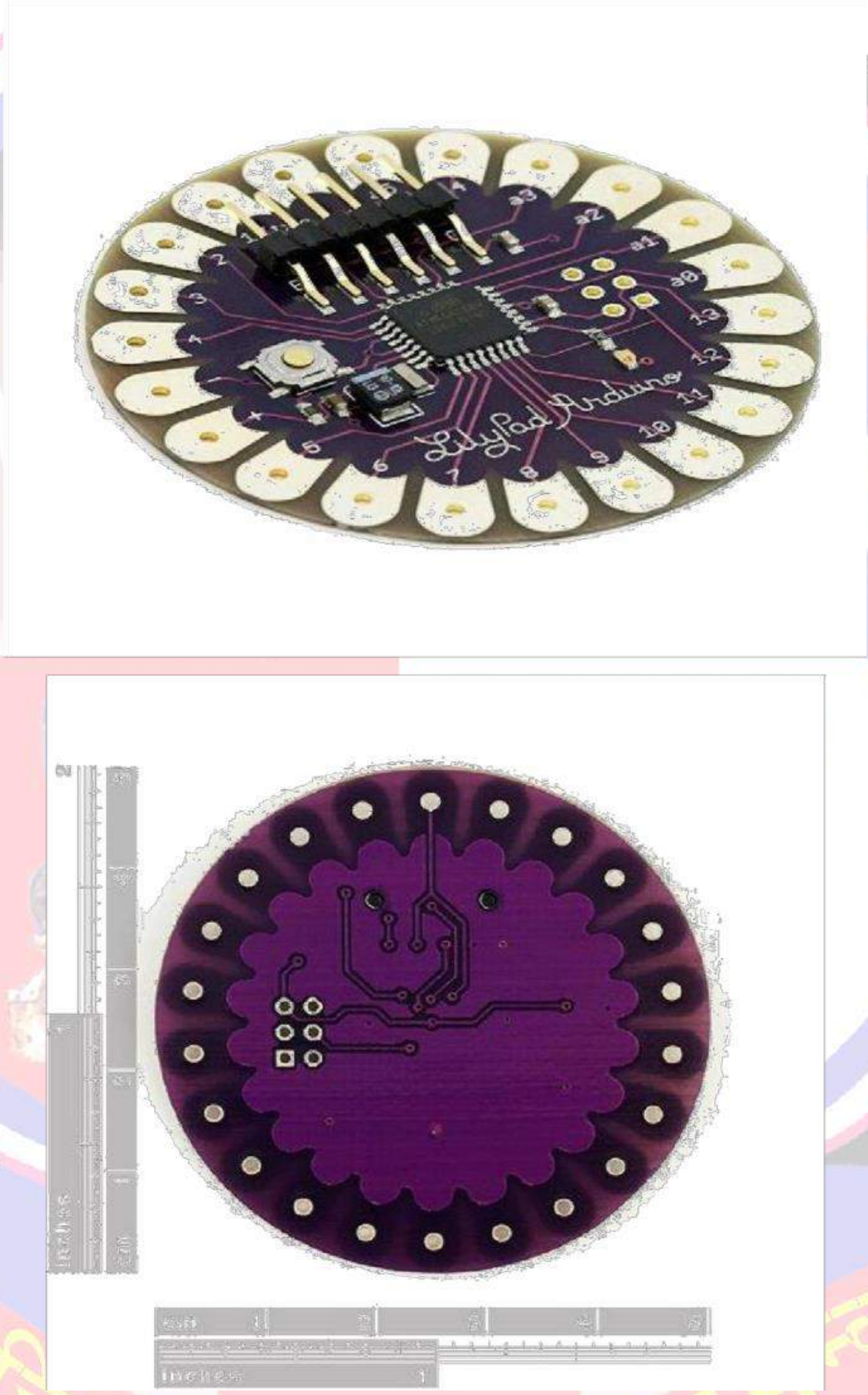


Figure 3.6.1: Lily pad [15]

Lily-Pad Arduino - the main board consisting of an ATmega328 with the Arduino boot loader and a minimum number of external components to keep it as small and as simple as possible. It can be attached on the palm of hand and can be used. Board will run from 2 volts to 5 volts. The latest version of the Lily-Pad supports automatic reset for even easier programming. The back side of the Lily-Pad is now completely flat! We now use a surface mount programming connector to keep the header from poking through. This version of the Lily-Pad now uses the new ATmega328 at 8MHz. Arduino 0016 supports the Arduino Pro Mini 328/8MHz. Use this setting when using this new Lily-Pad 328. Lily-Pad is a wearable e-textile technology developed by Leah Buechley and cooperatively designed by Leah and Spark Fun

Each Lily-Pad was creatively designed to have large connecting pads to allow them to be sewn into clothing. Various input, output, power, and sensor boards are available. They're even washable.

3.6.1 Operation

The Lily-Pad Arduino Simple Board is a small sew able computer. It can be stitched 3to fabric and connected to other electronic pieces with conductive thread. This Lily-Pad board has 11 pins — the silver petal-like tabs that ring the outside of the board. Each of these pins, with the exception of (+) and (-), can control an attached input or output device (like a light, motor, or switch). This board is based on the ATmega328V microcontroller. The microcontroller is the black square in the centre of the board (top view). You can program this Lily-Pad board using the Arduino programming environment.

3.6.2 Features

• Total pins	11 V
• Digital I/O pins	9 V
• Analog input pins	4 V
• PWM pins	5 V
• Power board requires	2.7 V to 5.5 Volts

3.7 Constraints

3.7.1 MATLAB, DSO – Generation of the guitar string sound

Initial assumptions were to generate guitar strings by using the distance measuring techniques of ultrasonic sensors and by using Arduino board. Work started in from the previous assumptions and it led to certain problems. To virtualize the conventional guitar the strings of the guitar had to be virtualized. For this purpose, we considered an ultrasonic sensor to be used along with Arduino to generate guitar string sounds. The sensor was used to generate the distance from the movements of an obstacle i.e. the plectrum in a guitar. This distance would be converted to a frequency using the microcontroller from a pre - defined algorithm. These frequencies were levelled. The levels were set as per strings of a guitar. This was all done by programming the Arduino UNO. Arduino was programmed to ping for the corresponding frequency(s). We were successfully able to. generate the sound of the strings of guitar. To store the sound was not an option as we had less memory and the size of the music file i.e. the mp3 file of the guitar string was large. MATLAB was used to generate the exact sound using an algorithm that would play almost the same sound of the string. Various ways were employed in order to generate the guitar sound. We made the use of combinations of sine waves to generate the graphs shown below.

Figure No. 3.7.1: Guitar Output Wave, E, B and G string

3.7.2 Graphical Outcome

The maximum possible graphical outcome that was generated from combinations of sine waves is as shown below compared to the original in DSO.

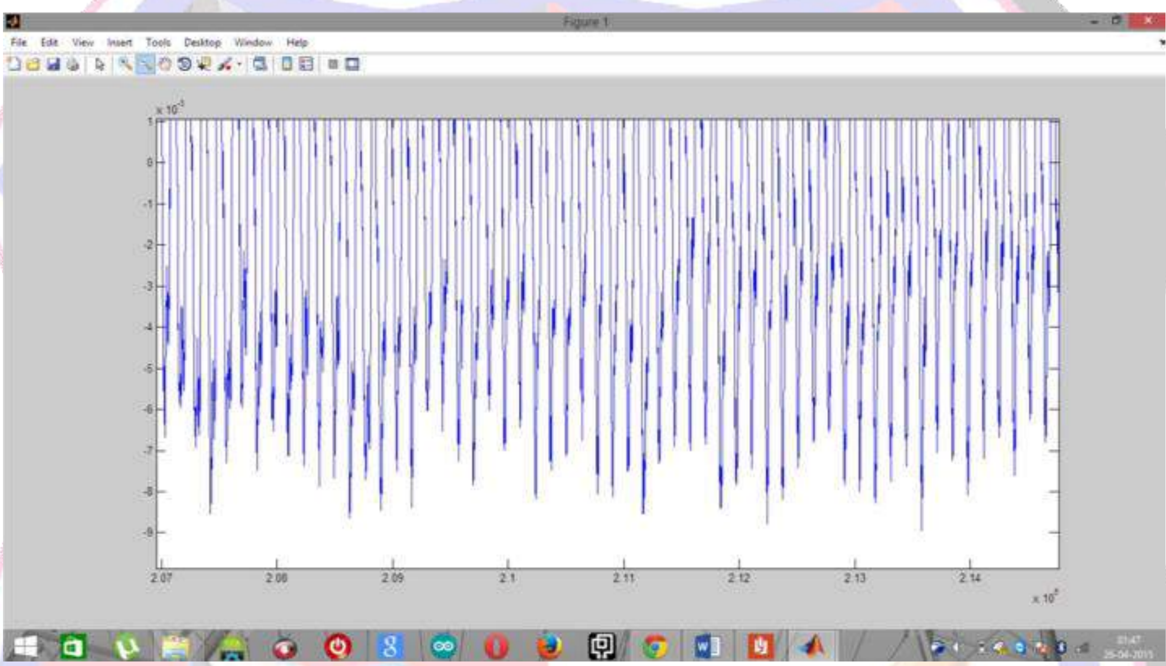


Figure No. 3.7.2: Zoomed View of the MATLAB output of strings

The sound from the combination made was not as the conventional guitar string sound. To store the file and play was the only option left. The available memory in Arduino, as it provides the feature of wave file storage does not have enough memory to store. The use of SD card to store music files in Arduino was an option.

The next challenge was to play the different strings of the guitar. The ultrasonic sensors can be kept in a row and the sound be played. The beam width of the ultrasonic sensor being small, connecting ultrasonic sensors in a row thus causes the interference of sound waves from one sensor to another creating a problem. The beam width interference distance is around 10 to 15 cms. This makes it difficult to switch sound from one string to another i.e. emission of sound and detection of the echo by the same sensor connected in a row and playing all six strings would be impossible.

Table 3.7 Controller Comparison

Comparison	Arduino	Raspberry pi
Memory	0.002MB	512MB
Flash	32KB	SD Card (2 to 16GB)
Input voltage	7 to 12 V	5V
OS	N/A	Linux distributions
Integrated Development Environment	Arduino	Scratch, IDLE, anything with Linux support
On board network	N/A	10/100 wired Ethernet RJ45
Clock Speed	16 MHz	700 MHz
Multitasking	No	Yes
USB	One, only input	Four, peripherals OK
Size	7.6 x 1.9 x 6.4 cm	8.6 x 5.4 x 1.7 cm
GPIO	14	40
Processor	AT Mega 328	ARM11
Audio	N/A	HDMI, Analog
Video	N/A	HDMI, Analog
Ethernet	N/A	10/100

3.8 Ultrasonic sensor to Accelerometer:

The next challenge was to play the different strings of the guitar. The ultrasonic sensors can be kept in a row and the sound be played. The beam width of the ultrasonic sensor being small, connecting ultrasonic sensors in a row thus causes the interference of sound waves from one sensor to another creating a problem. The beam width interference distance is around 10 to 15 cms. This makes it difficult to switch sound from one string to another i.e. emission of sound and detection of the echo by the same sensor connected in a row and playing all six strings would be impossible

The ultrasonic sensor was then replaced with an accelerometer which provided the functionality of playing all the 6 strings. Since there was only one accelerometer, interference was no more a problem. Accelerometer would be programmed in such a way that it would play all the 6 strings in a row depending on the distance and thus completing the requirement.

Chapter 4 Project Implementation

- **Project definition**

Virtual Guitar will be an instrument which will play the tunes of a guitar without the conventional guitar strings and wooden case.

- **Flow Chart**

Below given is the flow diagram of the entire system which will give entire view of the system to be made:

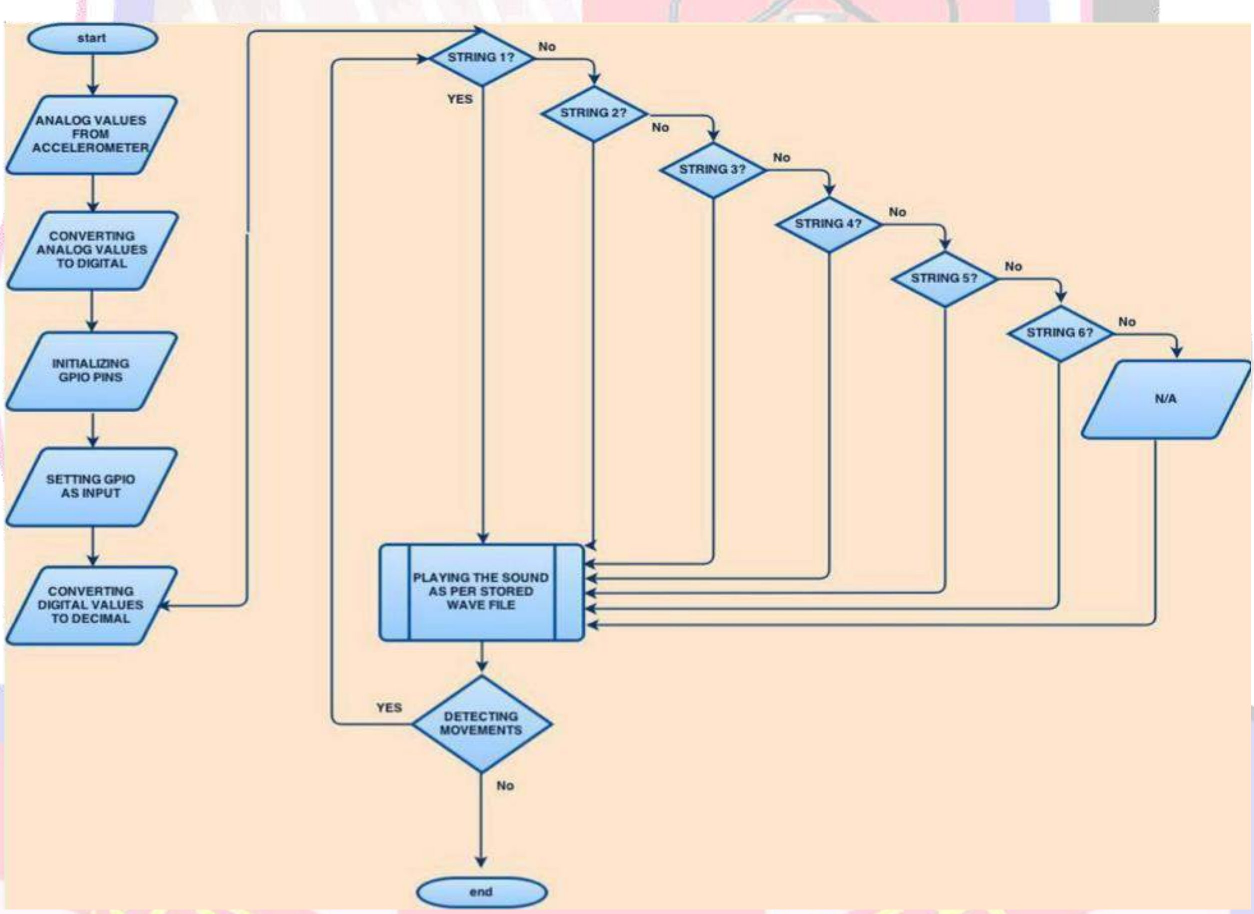


Figure No. 4.2.1: Flow Diagram

4.3 Block Diagram 2

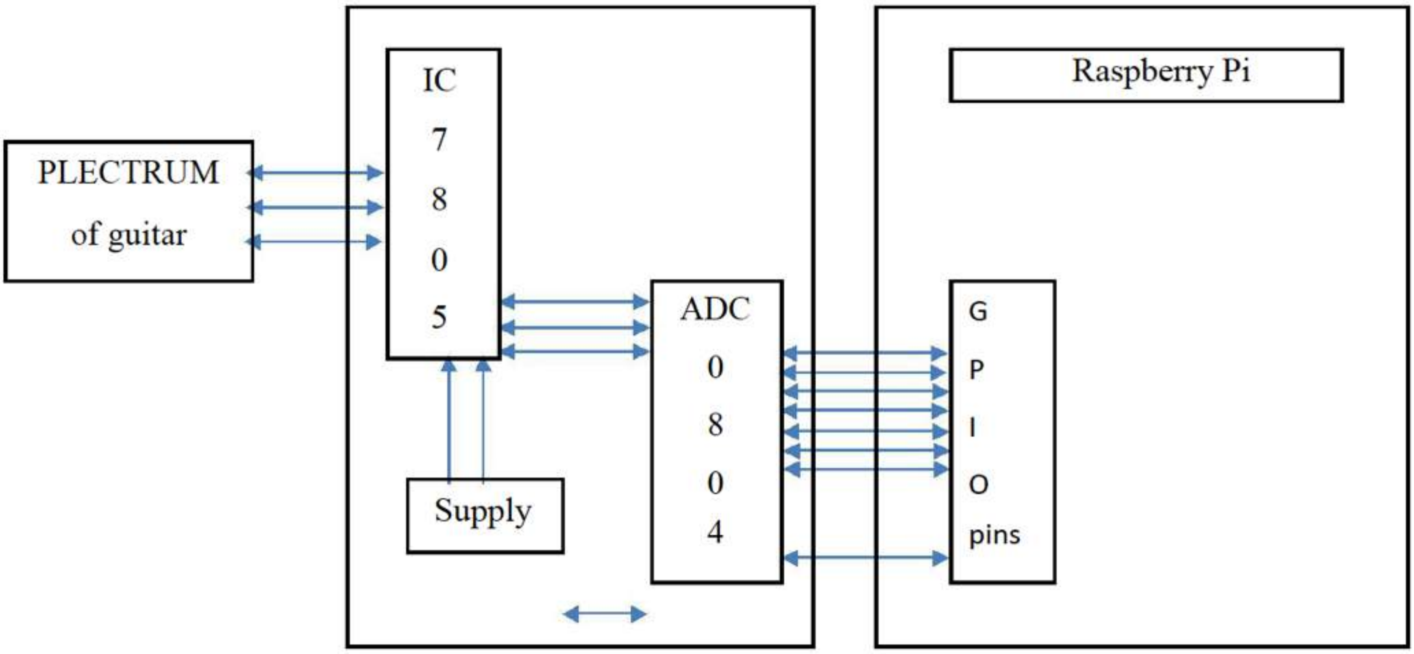


Figure No. 4.3.1: Block diagram 2

Description

As shown in the given figure consider an accelerometer. The accelerometer replaces the plectrum in the conventional guitar. The plectrum is used for the strumming purpose in the guitar; same way is the accelerometer used here in the virtual guitar. A power supply is given to the accelerometer i.e. 5 Volts by the IC 7805 mounted on the main PCB. The accelerometer is moved up and down along a particular direction and as per the principle of accelerometer, the analog values are generated and passed on to the PCB.

The IC 7805 supplies a constant 5 Voltage to the ADC 0804. The analog values passed on by the accelerometer are to be converted to digital values so as to pass it on to Raspberry Pi GPIO pins.

The ADC mounted on the PCB, converts the analog values to digital values. These digital values are now to be converted to a particular form so as to play the appropriate string of the guitar.

Thus, the digital or the binary values are to be sent to the GPIO pins of the Raspberry Pi.

Different guitar strings are stored in the form of wave files containing the string sounds of the conventional guitar.

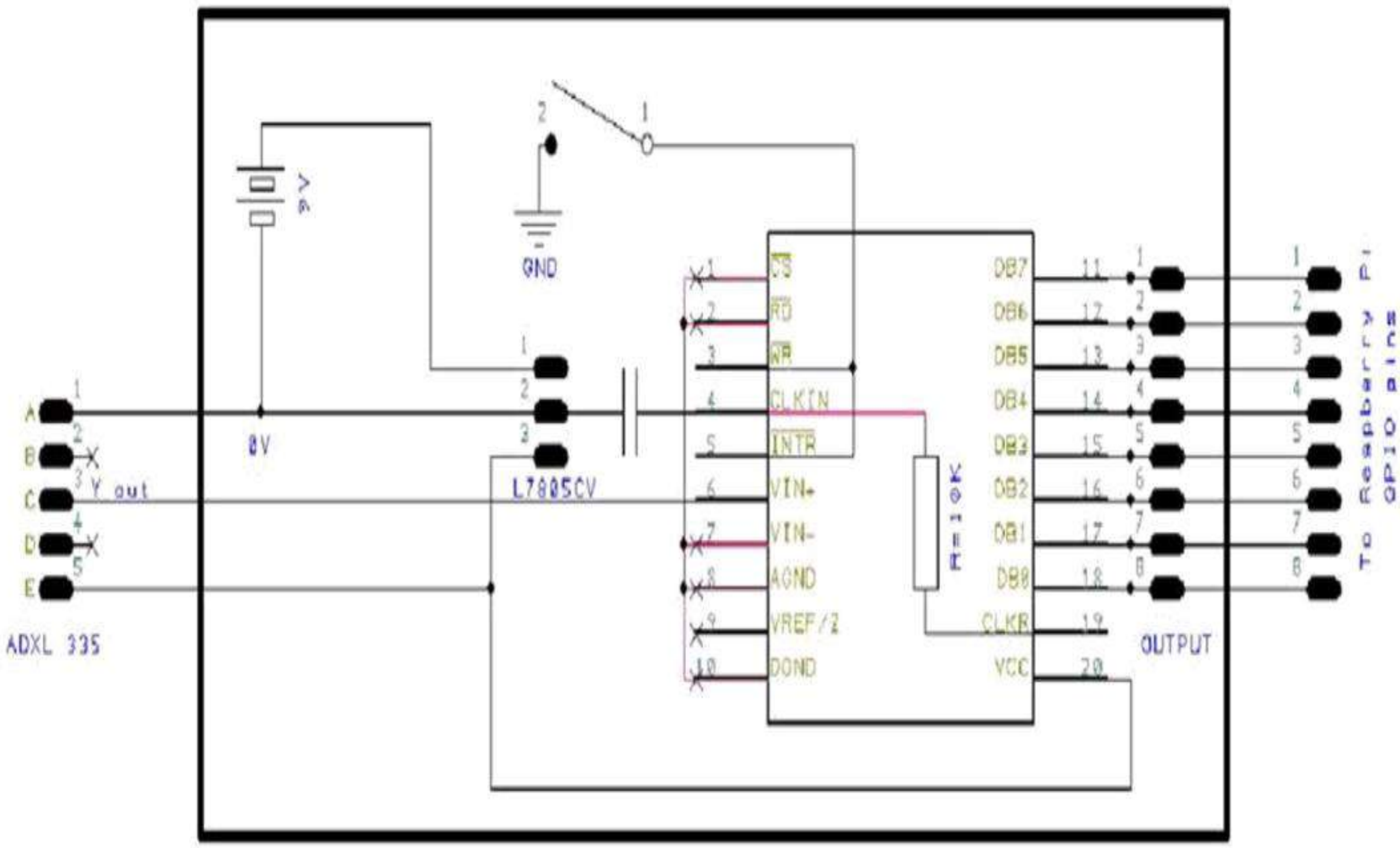
As, shown in the flow graph, the strings of the conventional guitar are made by divided the available area covered by the Accelerometer while moving up and down.

The program is based on such a algorithm that it itself divides available values into levels and thus forming the strings of the guitar.

If the accelerometer goes out of range, none of the stored wave files are played.

Thus, if the movement of the accelerometer is in range, then the particular wave file is played as per the level selected

Schematic



Algorithm

Step 1: The accelerometer is moved like the conventional guitar plectrum and the distance measured is transferred in the form of analog values to the ADC.

Step 2: ADC converts the analog values available from the accelerometer to digital values i.e. in the binary format.

Step 3: These values are then transferred to the raspberry pi GPIO pins as per the availability.

Step 4: The program then converts the digital values to the decimal values.

Step 5: The decimal values are divided in as per the distance between guitar strings.

Step 6: Thus, the sound is played after the movement of accelerometer.

4.4 Components

4.4.1 Accelerometer

An accelerometer is an electromechanical device which will measure acceleration forces. These forces may be static or dynamic, like force caused by moving or vibrating the accelerometer. By measuring the amount of static acceleration due to gravity, one can find the angle at which the device is tilted. By sensing the amount of dynamic acceleration, one can analyse the way in which device is moving. Accelerometers generally use the piezoelectric effect

i.e. they have microscopic crystal structures that get affected by accelerative forces as a result of which voltage is generated.

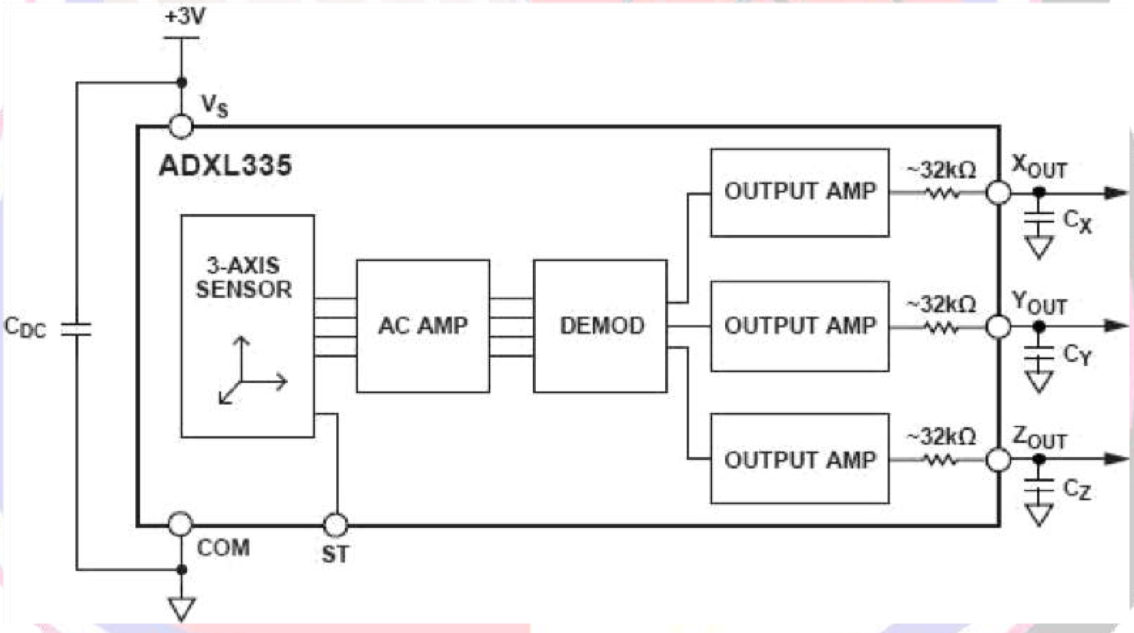


Figure 4.4.1: ADXL 335 [20]

The ADXL335 is a small, thin, low power, complete 3-axis accelerometer with signal conditioned voltage outputs. The product measures acceleration with a minimum full-scale range of ±3 *g*. It can measure the static acceleration of gravity in tilt-sensing applications, as well as dynamic acceleration resulting from motion, shock, or vibration. It contains a polysilicon surface-micro machined sensor and signal conditioning circuitry to implement an open-loop acceleration measurement architecture. The output signals are analog voltages that are proportional to acceleration.

The ADXL335 is available in a small, low profile, 4 mm × 4 mm × 1.45 mm, 16-lead, plastic lead frame chip scale package

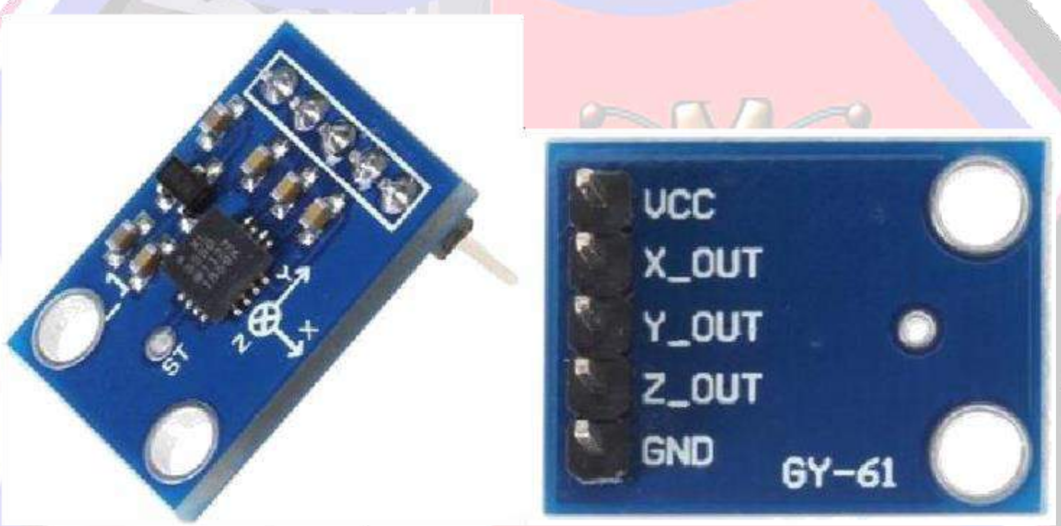


Figure 4.4.2 Accelerometer [21]

Table 4.4.1 Accelerometer

Sensitivity	3-axis
Size	4 mm × 4 mm × 1.45 mm LFCSP
Low power	350 µ A (typical)
Single-supply operation	1.8 V to 3.6 V
Feature	10,000 *g* shock survival
Stability	Excellent temperature stability
Adjustable axis	BW adjustment with a single capacitor per axis

4.5 Raspberry Pi

The Raspberry Pi is a single board minicomputer developed in the UK by the Raspberry Pi Foundation. The Raspberry Pi is ID card sized minicomputer that can be plugged to TV and a keyboard and also a mouse. Raspberry Pi has the ability to interact with the outside world and has it has been widely used in digital projects, from music instruments and detectors to weather forecasting stations It is a capable mini device that enables people to explore computing, and it works on programming languages like Python.

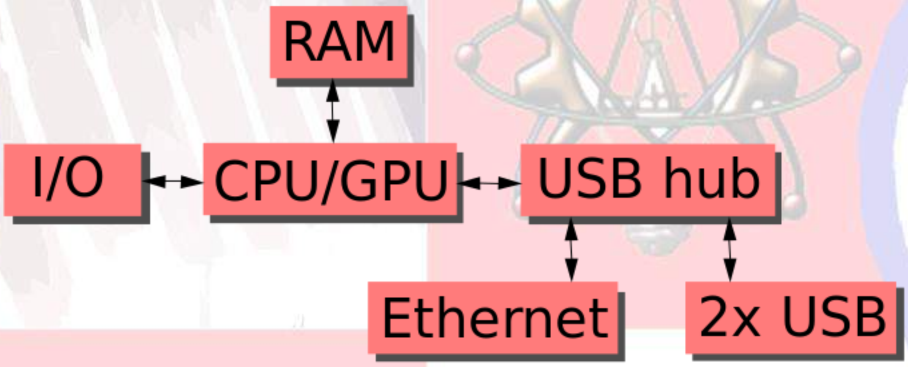


Figure 4.5.1 Raspberry Pi 1[25]

A, *B*, *A+*, *B+* are the Raspberry Pi models available in the market. Model A and A+ were very basic level model and so were not able to satisfy the project needs and B+ model had more features which were not necessary, so B model was preferred as it being the intermediate model and satisfying the needs of project.

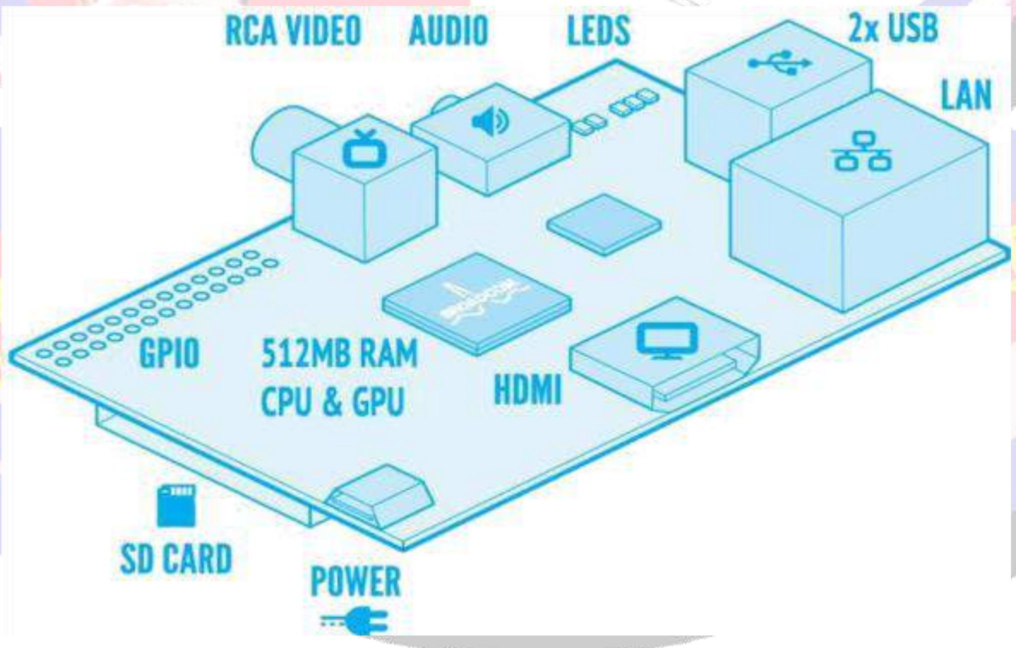


Figure 4.5.2 Raspberry Pi 1[25]

Reasons for selecting model B over model A are given below:

Table 4.5 Product details

Specification	Model A	Model B
Memory	256MB RAM	512MB RAM
Ethernet	N/A	Ethernet RJ45 j
USB	Single	Dual

Figure 4.5.2 Raspberry pi 2

Model B is a higher-end variant of the Raspberry Pi. Dual USB connector helps us to connect both keyboard and mouse for making the working simpler. Ethernet helps to connect Raspberry Pi directly to laptop without the using very costly HDMI to VGA cable.

The Raspberry Pi does not come with a real-time clock, so an OS must use a network time server, or ask the user for time information at boot time to get access to time and date info for file time and date stamping. However, a real time clock (such as the DS1307) with battery backup can be easily added via the I2C interface. Adafruit makes many accessories and starter kits for the Raspberry Pi, check them out in our Raspberry Pi section.

Figure 4.5.3: ARM I.C. [22]

System-on-chip is a Broadcom BCM2835. This contains an ARM11 using an ARMv6-architecture core with floating point, which runs at 700 MHz, and a Video-core 4 GPU (Graphic Processing Unit).

The ARM11™ processor family provides the engine that powers many smartphones in production today and is also widely used in
consumer, home, and embedded applications. It delivers extreme low power and a range of performance from 350 MHz in small area designs up to 1 GHz in speed-optimized designs in 45 and 65 nm. ARM11 processor software is compatible with all previous generations of ARM processors, and introduces
32-bit SIMD for media processing, physically tagged caches to
improve OS context switch performance, Trust Zone for hardware- enforced security, and tightly couple memories for real-time application

4.5 ADC 0804 PinOut

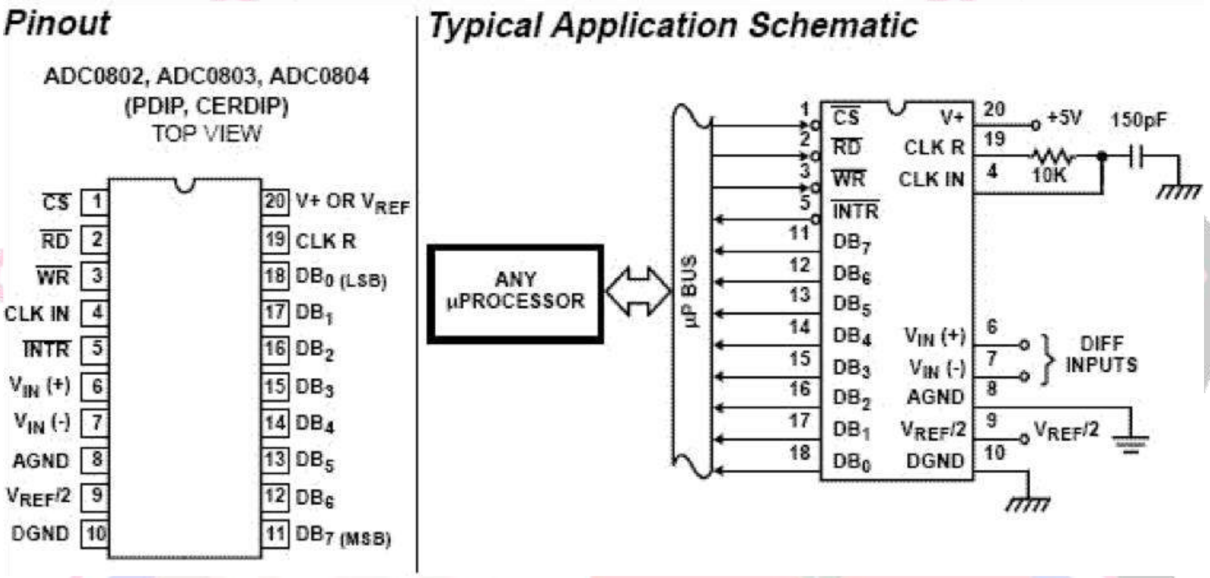


Figure 4.6.1: ADC 0804 1 [23]

Analog to digital converters find huge application as an intermediate device to convert the signals from analog to digital form. These digital signals are used for further processing by the digital processors. Various sensors like temperature, pressure, force etc. convert the physical characteristics into electrical signals that are analog in nature.

ADC0804 is a very commonly used 8-bit analog to digital convertor. It is a single channel IC, *i.e.*, it can take only one analog signal as input. The digital outputs vary from 0 to a maximum of 255. The step size can be adjusted by setting the reference voltage at pin9. When this pin is not connected, the default reference voltage is the operating voltage, *i.e.*, Vcc. The step size at 5V is 19.53mV (5V/255), *i.e.*, for every 19.53mV rise in the analog input, the output varies by 1 unit. To set a particular voltage level as the reference value, this pin is connected to half the voltage. For example, to set a reference of 4V (Vref), pin9 is connected to 2V (Vref/2), thereby reducing the step size to 15.62mV (4V/255).

Figure 4.6.2: ADC 0804 2

ADC0804 needs a clock to operate. The time taken to convert the analog value to digital value is dependent on this clock source. An external clock can be given at the Clock IN pin. ADC 0804 also has an inbuilt clock which can be used in absence of external clock. A suitable RC circuit is connected between the Clock IN and Clock R pins to use the internal clock

4.7 IC 7805

A voltage regulator is an electronic circuitry which is widely used in many devices. It provides a constant regulated voltage without any fluctuations & noise which is very important for the smooth and error –free functioning of any electronic devices. Voltage regulators are of different types. In here main focus is on IC based voltage regulators.

The 78xx ICs are fixed linear voltage regulators. The 78xx family is commonly used in circuits requiring a regulated fixed power supply as it is easy to use and as its cost is low. In here the *xx* is replaced with two digits, indicating the output voltage. The 78xx line are positive voltage regulators i.e. they produce a voltage that is positive relative to a common ground.

Components used in this project require 5V supply and thus, 7805 IC is selected.

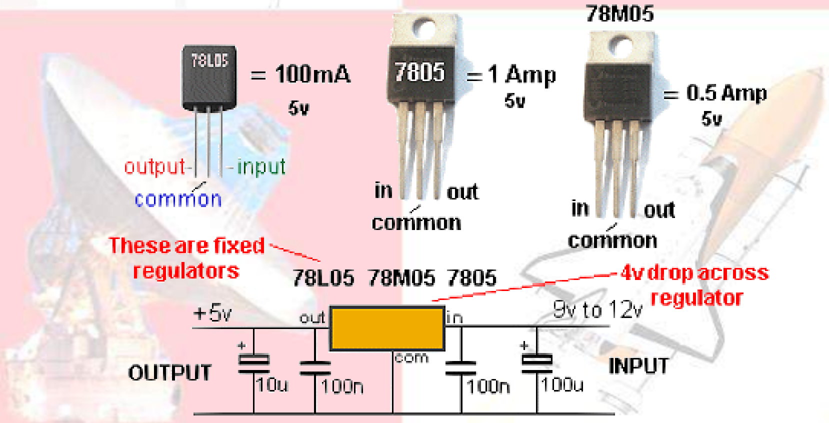


Figure No. 4.7.1: IC LM7805 [26]

This IC provides a constant voltage of 5V at its output. Input voltage can range from 5V to 18V whereas it provides output from 4.8 to 5.2V.

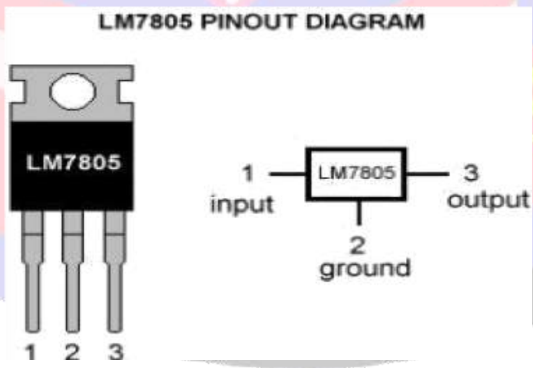


Figure No. 4.7.2: IC LM7805 [27]

4.8 Code Algorithm (program):

Below given is a small description of the program of the project via algorithm. The flow here describes the flow of the data.

Step 1: Importing the required libraries namely Pygame, GPIO, time. Step 2: Initializing the pins as input and output.

Step 3: Setting the infinite loop to check continuously for the input from accelerometer.

Step 4: The strings are to be divided in levels w.r.t. the number of strings in the conventional guitar.

Step 5: Inputs in the form of binary are collected in the different variables.

Step 6: These binary inputs are converted to decimal values by the logic displayed in the program

Step 7: These values will now be selected as per the levels shown in the program as per the strings of virtual guitar

Chapter 5 Conclusion

As per the reasons stated above, virtual guitar can be preferred over conventional guitar.

5.1 Advantages of the project:

The current project has nothing to deal with the wooden case. Thus, there because of no wooden case to handle with or to carry unlike the conventional guitar where a person has to carry the whole guitar (while moving from one place to another) the guitarist will be able to easily carry the guitar. This may also be favourable compared to the space occupied by the conventional guitar wherein the current innovation occupies a small space, for instance a box.

The conventional guitar consists of strings; the number depending on the type of guitar. These strings have to be changes every 8 to 10 months as a concern to the maintenance of the guitar or even due to the breaking of the strings while tightening the nob on the top may break the strings. These strings are costly. The current innovation work on the technology of sound waves which are invisible and thus no problems like breaking of strings occurs.

The tuning is a very important factor which deals with the sound generation. To play the guitar with its perfect pleasant sound tuning is required. But in the current innovation the sound stored are already in its best form so no need to tune.

The conventional guitars require an amplifier to play whereas the current project because of the use of Raspberry pi will be able to play the music in the ear plugs providing an extra facility.

5.2 Future Work

The future work will be divided into two phases for the development of chords in order to take the project to the next level:

The playing of the conventional guitars can be classified into the lead part and the chord part. The current project will be able to play the lead part and chord part. The making of the chord part can be divided as follows:

5.2.1 Flexion sensors

Flex sensors also called **bend sensors**, measure the amount of deflection caused by bending the sensor. They measure the change in resistance as shown below.

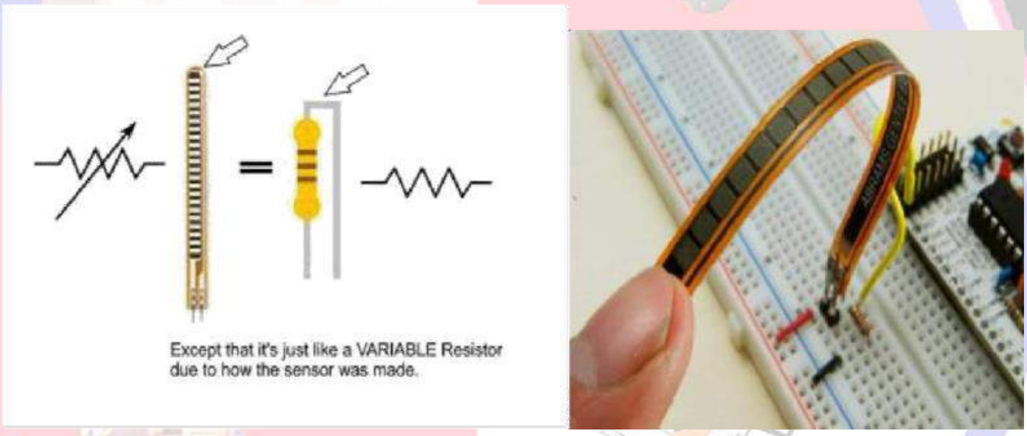


Figure 5.2.1 Flex sensor

These sensors will be used to make the chords of the guitars depending on bending of the sensors. It can be seen as shown below equipped on a glove.

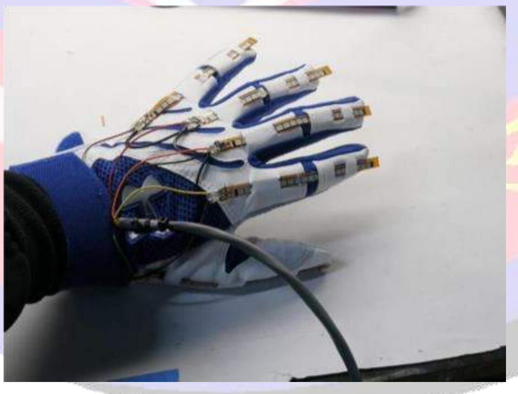


Figure 5.2.2 Glove

5.2.2 Digital Logic

PCB development was done from the scratch. has been develop to serve the purpose of the chord generation. Here a combination of cowboy chords namely the majors and minors of E, F, G, C, A and the D chords can be developed by a digital logic as in the PCB. Thus by generating guitar chords we will be able to give the guitar feel.

- Designed the schematics
- Printed them
- Prepare copper clad board
- Toner transferred to board
- Washed the Board
- Removed paper
- Applied etching technique
- Washed it
- Removed the PCB
- Drilled

Figure 5.3.1 Chord Maker

5.3 Conclusion

By our project we have designed a prototype that has brought an advancement in the Music Industry. Guitar is made a handy tool. Problems listed above that are faced with conventional guitar are eliminated on a technological level. We are also looking forward to developing this concept that would enable the beginners to learn to play guitar.

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Appendix

Program Python Code

```
import RPi.GPIO as GPIO import time
import pygame pygame.mixer.init()

GPIO.setmode(GPIO.BOARD)
GPIO.setup(3,GPIO.IN)
GPIO.setup(7,GPIO.IN)
GPIO.setup(11,GPIO.IN)
GPIO.setup(12,GPIO.IN)
GPIO.setup(13,GPIO.IN)
GPIO.setup(15,GPIO.IN)
GPIO.setup(16,GPIO.IN)
GPIO.setup(18,GPIO.IN)
GPIO.setup(22,GPIO.OUT)
GPIO.output(22,True)

while 1:
if GOP.input(3):
    s0 = 1
else: s0 = 0

if GPIO.input(7):
    s1 = 1
else: s1 = 0

if GPIO.input(11):
    s2=1
else: s2 = 0

if GPIO.input(12):
    s3 = 1
else: s3 = 0

if GPIO.input(13):
    s4 = 1
else: s4 = 0

if GPIO.input(15):
    s5 = 1
else: s5 = 0

if GPIO.input(16):
    s6 = 1
else: s6 = 0

if GPIO.input(18):
    s7 = 1
else: s7 = 0
```

```
x = a1*1 + a2*4 + a3*8 + a4*16 + a5*32 + a6*64 + a7*128 + a8*256
if x<32: pygame.mixer.music.load("2.wav")
pygame.mixer.music.play()
while pygame.mixer.music.get_busy() == True: continue
elif x>32 and x<64:
pygame.mixer.music.load("1.wav")
pygame.mixer.music.play()

while pygame.mixer.music.get_busy() == True: continue
elif x>64 and x<128:
pygame.mixer.music.load("3rd_String_G_(4th.wav")
pygame.mixer.music.play()

while pygame.mixer.music.get_busy() == True: continue
elif x>128 and x<160:
pygame.mixer.music.load("4th_String_D_(4th.wav")
pygame.mixer.music.play()

while pygame.mixer.music.get_busy() == True:
continue elif x>160 and x<256:
pygame.mixer.music.load("5th_string_A_(4th.wav")
pygame.mixer.music.play()

while pygame.mixer.music.get_busy() == True: continue
elif x>256:
pygame.mixer.music.load("6th_String_E_(4th.wav")
pygame.mixer.music.play()
while pygame.mixer.music.get_busy() == True:
continue
```