

Vibration Sensor Triggered Led Display Board Using Piezo Electric Transducer

D. Vijayakumar¹, P. Manoj Kumar², P. Sai Chandra Mouli³, R. Sai Kumar⁴, S. Suresh⁵

¹Professor and HOD, Department of EEE, Aditya Institute of Technology and management

^{2,3,4,5} UG Scholar, Department of EEE, Aditya Institute of technology and management

Abstract- Piezoelectricity is going to create more energy for the world than any other renewable resource. It takes pressure upon crystals and creates energy. No other resource can be fully sustained simply putting crystals within our own structures. This energy source will be fundamental to the world one day going completely green and supplying our energy by our own movements.

In this project with the application of Piezo electricity, the vibrations generated by our foot pressure while walking were used to generate small amount of Piezoelectricity by means of a piezoelectric transducer or crystal. Thus produced small amount of Piezoelectricity is amplified using an Op-Amp based non-inverting amplifier and that amplified voltage is compared with the 5V D.C supply which are combinedly given to Op-Amp based comparator. That differential output is given to the Arduino UNO. The Arduino is programmed in such a way that whenever the differential output is received by 8th pin of Arduino, then it should transmit a signal through HC-05 master Bluetooth module.

That signal was received by the slave HC-05 Bluetooth module and given to the receiver side Arduino which was connected with the LED display board. The receiver side Arduino is programmed to scroll the text only when it receives the signal from the transmitter.

I. INTRODUCTION

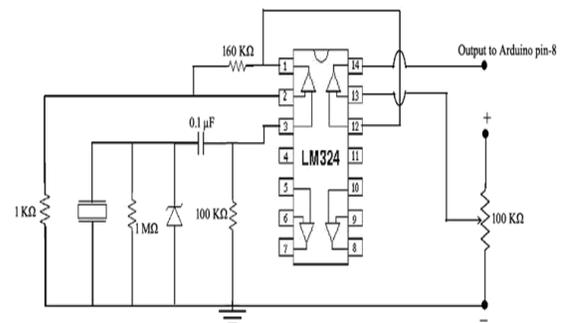
Our project is mainly based upon one of the application of Piezo electricity. Piezoelectricity, also called the piezoelectric effect, is the ability of certain materials to generate an AC (alternating current) voltage when subjected to mechanical stress or vibration, or to vibrate when subjected to an AC voltage, or both. The most common piezoelectric material is quartz.

In this project we have utilized the voltage produced by applying pressure on the Piezo electric transducer for triggering the LED display board. The pressure is

applied on the Piezo electric transducer in the form of foot pressure while walking.

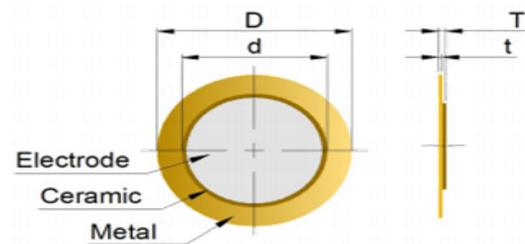
The entire project is comprising of two circuits both are communicated wirelessly by means of Bluetooth modules. First circuit is for the vibration sensor circuit for triggering and the second one is at the LED display board.

Vibration sensor circuit:



Components in triggering circuit:

Piezo electric transducer:



A piezoelectric transducer comprises a "crystal" sandwiched between two metal plates. When a sound wave strikes one or both of the plates, the plates vibrate. The crystal picks up this vibration, which it translates into a weak AC voltage. Therefore, an AC voltage arises between the two metal plates, with a waveform similar to that of the sound waves. Conversely, if an AC signal is applied to the plates, it causes the crystal to vibrate in sync with the signal

voltage. As a result, the metal plates vibrate also, producing an acoustic disturbance.

Since the transducer has a very good HF response, its principal use is in HF accelerometers. In this application, its output voltage is typically of the order of 1-30 mV per gram of acceleration. The device needs no external power source and is therefore self-generating. The disadvantage is that it cannot measure static conditions. The output voltage is also affected by temperature variation of the crystal.

The basic expression for output voltage E is

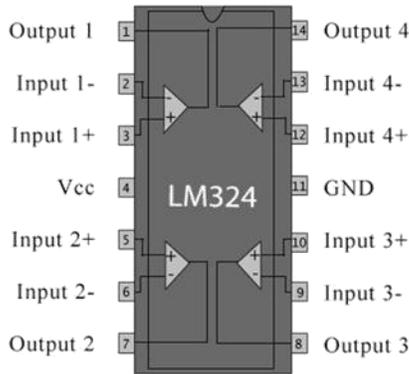
$$E = \frac{Q}{C_p}$$

given by

Where

Q = generated charge

C_p = shunt capacitances



LM 324-Low power quad op-amp:

The LM324 series are low-cost, quad op-amps with true differential inputs. They have several distinct advantages over standard operational amplifier types in single supply applications. The raw output of the Piezo unsuitable for direct input to the Arduino as it is typically a very small voltage signal and needs amplification, so I amplify the signal from the Piezo with a 221 gain non-inverting op-amp using one side of an LM324. I use the other side of the LM358 for a comparator.

Features of LM-324:

- Short Circuited Protected Outputs
- True Differential Input Stage
- Single Supply Operation: 3.0 V to 32 V (LM224, LM324, LM324A)
- Low Input Bias Currents: 100nA Maximum (LM324A)
- Four Amplifiers Per Package

- Internally Compensated
- Common Mode Range Extends to Negative Supply
- Industry Standard Pinouts

Zener Diode:



A Zener diode is a particular type of diode that, unlike a normal one, allows current to flow not only from its anode to its cathode, but also in the reverse direction, when the Zener voltage is reached.

Zener diodes differ from regular diodes in that they have a varying "reverse-breakdown" voltage. That means you apply voltage across them, and when a preset voltage is reached, they start conducting. A common analogy is a "pressure relief valve". They have lots of uses, especially in safety circuits where you want to make sure a voltage signal doesn't exceed a limit that might damage the circuit.

Specifications of Zener diode:

- Voltage - Zener (Nom) (V_z): 5.1VDC
- Power - Max: 1W
- Impedance(Max) (Z_{zt}): 7 Ohm
- Voltage - Forward (V_f) (Max) @ If: 5.355VDC
- Current - Reverse Leakage @ V_r: 10µA @ 1V
- Tolerance: ±5%
- Mounting Type: Through Hole, Axial
- Package / Case: DO-41, Axial
- Operating Temperature: -65 - 200°C

Resistors:



The Piezo drives a load resistor of 1MΩ in parallel with a 5.1v Zener diode just to protect the IC's against any large voltage spikes in the event of a large physical bump.

The 100KΩ resistor is used as grounding resistor for the non-inverting amplifier.

The 1KΩ resistor along with 160KΩ feedback resistor forms a potential divider circuit.



The 160KΩ resistor is used as the feedback resistor for the non-inverting amplifier.

Potentiometer:



- The potentiometer used in this circuit is of 100KΩ
- This is used for adjusting the sensitivity of the Piezo electric transducer

By adjusting the variable resistor, the circumference of the vibration detection region can be increased or decreased based upon the requirement.



Capacitor:

A 0.1uF capacitor is placed in the circuit to connect the output from the piezo element to the input of the op-amp, also grounded on the op-amp side using a 100k resistor. This acted as a DC decoupler and effectively lowered the comparator threshold required to detect vibration.

Arduino Uno & Nano:

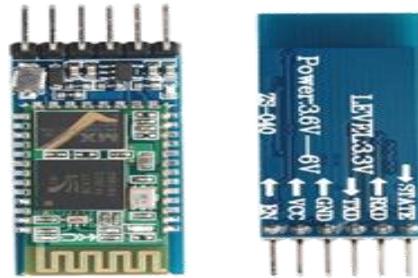


The output of the comparator is given to the digital pin 8. The Arduino is programmed in such a way that whenever there is an input high at the digital pin 8, then the TX pin i.e. pin1 gets activated and the transmitter Bluetooth module which is acting as

master transmits the signal to the receiver side Bluetooth module.

Also it serves as the voltage source for the entire vibration detection circuit as well as Bluetooth module.

HC-05 Bluetooth Module:



(Transmission side):

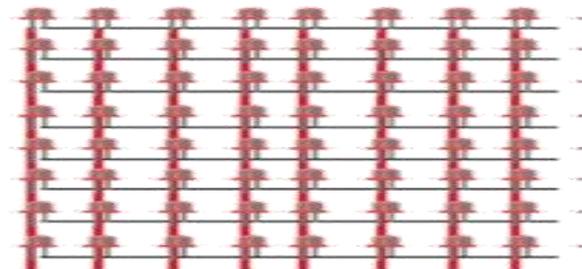
- The transmitter side Bluetooth module acts as master module.
- It transmits the signal obtained at TX pin of the transmitter side Arduino.
- Its input voltage range is 3.3V-5V
- It has 6 pins as shown in the figure beside
- Only VCC, GND, RXD, TXD pins are used in this project. Remaining pins are used for pairing.

(Receiver side):

- The receiver side Bluetooth module is same as the transmitter side module but their functioning is different.
- It acts as receiver of the signal which is obtained from the transmitter module.
- This module is acts as a slave as it obeys the master Bluetooth module.

LED Display board:

The LED display board consists of five 8×8 LED matrices for displaying the text input given to it. The LED's of each 8×8 matrix are connected as in the below image



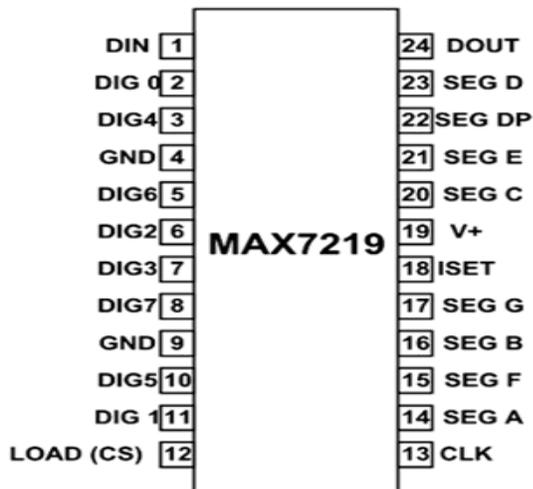
For each matrix, 8 anodes and 8 cathodes are obtained as follows



MAX7219CNG LED driver IC's:

MAX7219CNG is a programmable display driver integrated circuit that is used to control a large array of LEDs while consuming a relatively small number of GPIO pins. It receives input commands via four SPI pins, and uses these commands to drive either an 8x8 matrix of LEDs, or an eight-digit seven-segment display.

Pin diagram of MAX7219CNG:



Features of MAX7219CNG:

- 10MHz Serial Interface
- Individual LED Segment Control
- Decode/No-Decode Digit Selection
- 150µA Low-Power Shutdown (Data Retained)
- Digital and Analog Brightness Control
- Display Blanked on Power-Up
- Drive Common-Cathode LED Display

Electrical characteristics of MAX7219CNG:

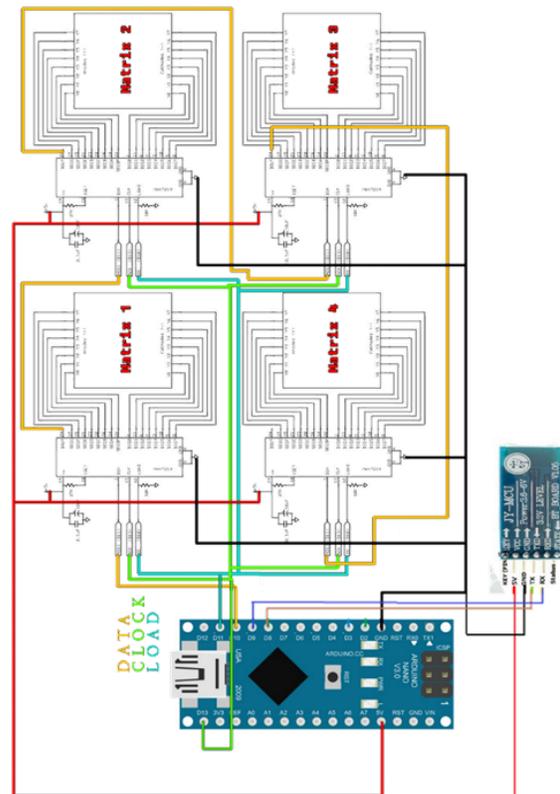
($V_+ = 5V \pm 10\%$, $R_{SET} = 9.53k\Omega \pm 1\%$, $T_A = T_{MIN}$ to T_{MAX})

- Operating Supply Voltage: 4.0V to 5.5V
- Operating Supply Current (RSET = open circuit): 8mA max.
- Display Scan Rate (8 digits scanned): 800Hz typ.
- Digit Drive Sink Current ($V_+ = 5V$, $V_{OUT} = 0.65V$): 320mA min.
- Digit Drive Source Current (Digit off, $V_{DIGIT} = (V_+ - 0.3V)$): -2mA min. Segment Drive Sink Current (Segment off, $V_{SEG} = 0.3V$): 5mA min.

Applications of MAX7219CNG:

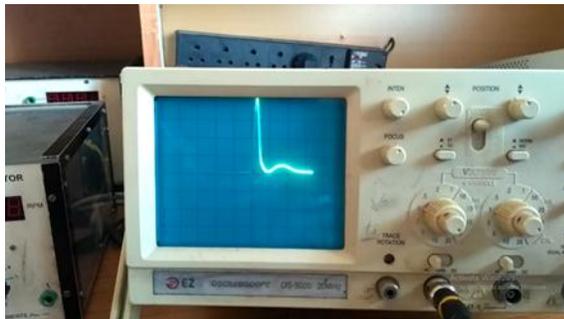
- Bar-Graph Displays
- Industrial Controllers
- Panel Meters
- LED Matrix Displays

The LED matrices are connected to their individual LED drivers and the connections between each other, with Arduino Nano and Bluetooth were represented in the circuit diagram below





RESULTS OBTAINED:



RESPONSE OF VIBRATION SENSOR CIRCUIT:

REFERENCES

- [1] For vibration sensing circuit we have referred a YouTube video by David Houlding. Link for the video is <https://youtu.be/ygFHyzrkwVk>
- [2] For circuit diagram and program for Arduino we visited the official BlogSpot of David Houlding. <http://davidholding.blogspot.com/2014/02/high-sensitivity-vibration-sensor-using.html>
- [3] We have referred a YouTube video by Electronoobs for making LED display board. Link for the video is https://youtu.be/v1vRjOU_pGA
- [4] We have used the schematics and program for Arduino from electronoobs official website http://www.electronoobs.com/eng_arduino_tut14.php