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Development of Automatic Piezoelectric Transducer Mesh System

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ABSTRACT

The core idea is development of a system which would help the automobile drivers to identify the density of pedestrians at the lanes and roads which are not big enough to have traffic signal, but still have a decent amount of traffic. It would help the drivers to identify the pedestrian density from a fair distance and thus adjust their speeds appropriately so as to avoid possible accidents. This would usually be helpful in areas like school zones as it would give the drivers a better visual indicator compared to sign boards and would remind them to keep their speed in control. The plan is to use an array made of piezo-electric transducers, which are connected to the voltage detection sensor, to measure the total voltage generated. Depending on the total voltage generated, it would be possible for the microcontroller to infer the density of people at a certain point and an appropriate signal is displayed on the LED screen, for the drivers to know from a fair share of distance. This method can help to avoid accidents better than the conventional methods of using sign boards as it is easily distinguishable compared to a sign board and can be used in the places like school zones, places where old people come to walk etc, where there aren't any appropriate traffic control measures.

Keywords: Detection system, piezo-electric transducer, mesh

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1. INTRODUCTION

Thegrowingpopulationincurrenterahasresultedinasurgeoftraffic.Ontopof that, congested roads which doesn't have any efficient traffic control system has beena major cause for accidents (1-3). A major part of these accidents is when the vehicles collidewith walking pedestrians. The reason for this to happen is the lack of informationregarding the pedestrians walking at tight corners and blind spots where the pedestriansmightnot bevisible tothe drivers.On top of that, lack of awareness of signboards is another factor causing to thesekinds of accidents. Another similar kind of problem is encountered in highways whereanimals which naturally doesn't have any sense for these traffic rules suddenly jump infront of vehicles causing collisions(4-8). These kinds of incidents result in either injuries toautomobile drivers or pedestrians, Thus, to avoid this issue, we have come up with an idea of pedestrian detection system.

In today's world of sophisticated mechanical, electromechanical and electronic applications, polymers are playing an increasingly important part. One of the most significant advantages of polymeric materials over other materials is their complex structure, which can be physically or chemically tailored for specific applications (9-13). Highly insulating polymers have been used extensively in electrical cable insulation since their invention in the first half of the 20th century. Some fluoropolymers were shown to store injected electrical charges for long periods of time, even at elevated temperatures. The discovery of piezoelectric and pyro electricity in polyvinylidene fluoride (PVDF) opened wide market for electromechanical transducer applications. In recent years, non-polar ferroelectrics with high piezoelectric coefficient have received a lot of attention. Already a new class of non- polar ferroelectrics based on charge storing polymers have become available in the market (14). Since the piezoelectric effect exhibited by natural materials such as quartz, tourmaline, Rochelle salt, etc. is limited in terms of usable power, polycrystalline ferroelectric ceramic Advances in Ceramics - Electric and Magnetic Ceramics, Bio ceramics, Ceramics and Environment materials such as barium titanate (BaTi03) and lead zirconate titanate (PZT) with improved properties have been developed over the last few decades. Likes of PZT ceramic are available in many variations and are still the most widely used materials for actuator applications today.

2.METHODOLOGY-HARDWARE IMPLEMENTATION

2.1 Piezo-electric Transducer

A transducer is something which converts one form of energy into another form.A transducer made of piezo electric materials is known as piezoelectric transducer. Apiezoelectric transducer (also known as a piezoelectric sensor) is a device that uses thepiezoelectric effect to measure changes in acceleration, pressure, strain, temperature orforce by converting this energy into an electrical charge. Under the action of mechanical stress, this transducer rgenerates voltage. This is called as piezo-electric effect.

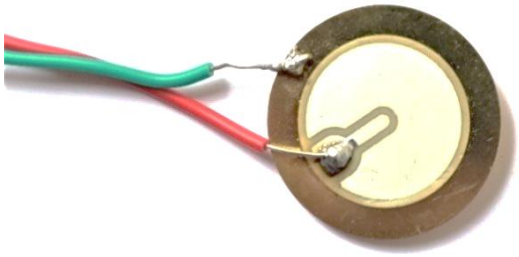

Fig.1Piezo-electricTransducer

2.2 Voltage Detection Sensor Module

Voltage detection sensor module is a low-cost voltage sensing device used to measure voltages in the range of 0-25V. This sensor is a perfect fit to determine the output voltages obtained from piezoelectric sensor.

Fig.2 Voltage Detection Sensor Module

2.3 LCD Module

It is an electronic display module that uses liquid crystal to produce visibleimages. It is used a basic 16X2 LCDDisplay. It has 2 lines consisting of 16characterseach.

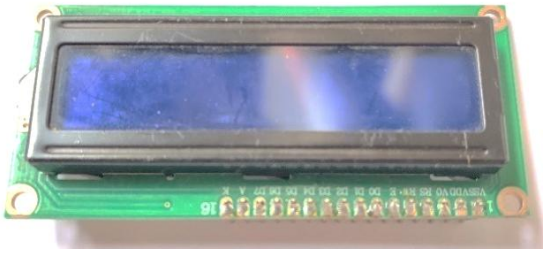

Fig.3LCDModule

2.4 Connecting Wires and Jumper Wires

These wires are used for establishing connections in the circuit. Male to male,maleto female andmainstreamconnecting wiresare usedhere.

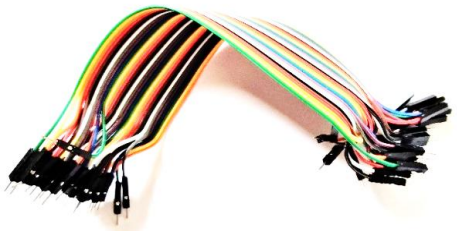

Fig.4 Connecting Wiresand Jumper Wires

2.5 Hard Foam covering

Foam covering is used in order to fix the piezoelectric sensors at a place and also to make sure that the sensors aren't damaged due to the forces applied on them.

2.6 Soft Foam – Force Dampers

Force dampers are used to absorb the extra force that is given to the system, in order to save the crucial parts of the system (Piezoelectric Transducer) from damage. These dampers shrink with the force given to them and transfer the force directly to the base Hard foam covering, which results in non-damage of the sensitive transducers.

Fig.5 Soft Foam–Force Dampers

2.7 Plastic Force Absorber

These are small plastic projections, that fix onto the piezoelectric transducers, and when applied force on them, directly pressing the crystals on the transducer, results the compression of the transducers, which generate the potential difference. The extra force applied on the entire arrangement, is absorbed by the soft foam compressions, protecting both hard plastic force absorber, and the piezoelectric transducer

2.8 Power Supply

A 9 Volts battery is used to supply the power for this system.

Fig.6 Power Supply–9vBattery

2.9 Microcontroller

Micro controller is the brain of any embedded system. Itis pin touse Arduino UNO as microcontroller. It is an open-source microcontroller boardconsisting of ATmega328 microchip. It has 14 digital input/output pins, 6 analog inputs,a 16 MHz ceramic resonator (CSTCE16M0V53-R0), a USB connection, a power jack,anICSPheader and areset button.

Fig.7Arduino UNO

3.WORKING PRINCIPLE

Designed and developed a mesh made of piezo electric transducer consisting of different blocks. Each block has three piezo electric sensors connected in series and they are connected in parallel with four other similar arrangements. Overall, there are five parallel arrangements in our prototype version of the block. However, while fabricating for large scale use, this order of arrangement can be changed. Each block is connected to a voltage sensor module to detect the voltage generated. For this prototype we are making two such blocks. Since the generated voltage from each sensor might not be same, as there might be different forces acting at different points of our foot, just check whether each block generates some voltage or not. Depending upon the number of voltage sensors detecting the voltages, we can determine the density of pedestrians at a certain point. This data is collected by Arduino and a message is generated on the LCD module describing the density of pedestrians at a place at certain time depending upon number of footsteps generated by the people walking.

3.1 BlockDiagram

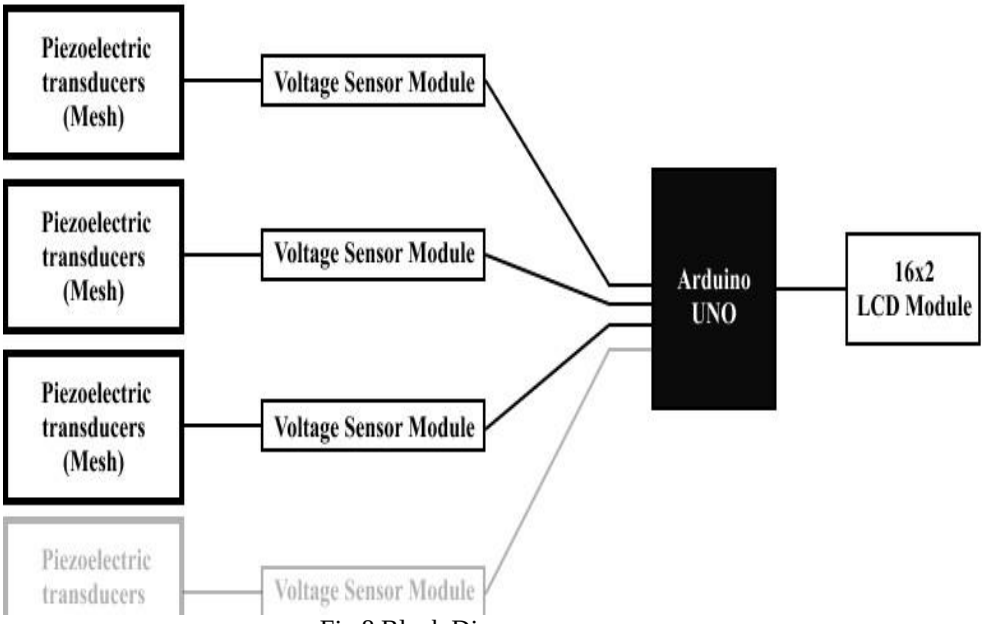

Fig.8 Block Diagram

3.2 PiezoElectricMeshArrangement

The piezoelectric transducers are connected in the following parallel and series combination forming a mesh like structure. Firstly, it connected three piezoelectric sensors in series and then we connected this arrangement in parallel with similar arrangements. Each sensor has a force absorber and force damper so that the force is actuated on the center of the piezoelectric transducer so that the output obtained is more. The force dampers are slots made on the inner foam covering while the force absorbers are made of rubber material and are placed at the center of the piezo electric transducer.

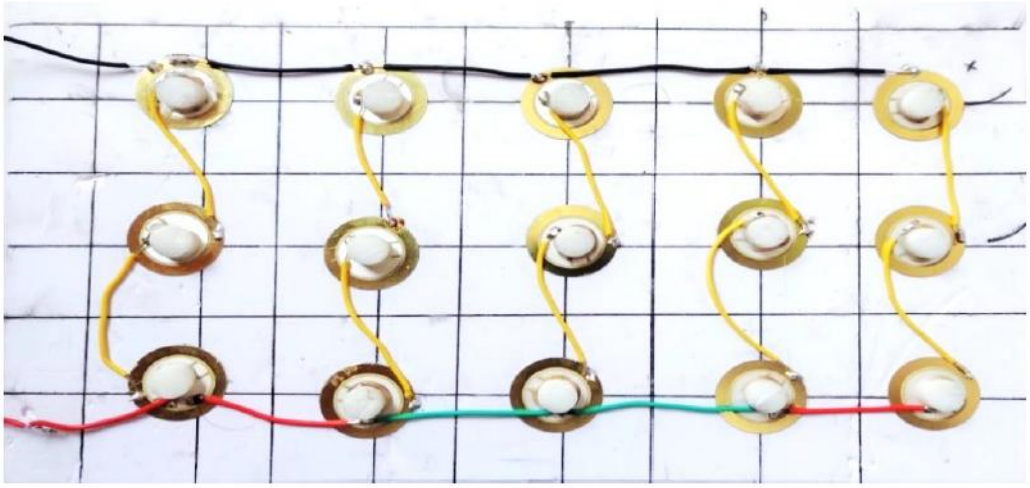

Fig.9 Piezo-electric Mesh Arrangement

3.3 CircuitDiagram

PiezoelectricTransducer

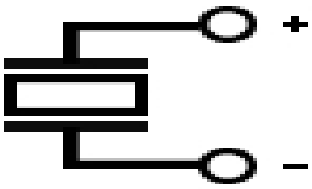

Fig.10 Piezoelectric Transducer Symbol

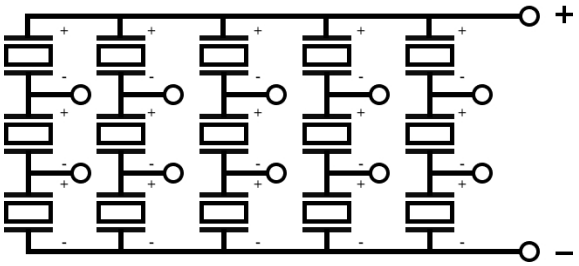

Fig.11 Piezoelectric Transducer Mesh arrangement

4. RESULTS AND DISCUSSION

The commonly measured physical quantities by a piezoelectric sensor are Acceleration and Pressure. Both pressure and acceleration sensors work on the same principle of piezoelectricity but the main difference between them is the way force is applied to their sensing element. In the pressure sensor, a thin membrane is placed on a massive base to transfer the applied force to the piezoelectric element. Upon application of pressure on this thin membrane, the piezoelectric material gets loaded and starts generating electrical voltages. The produced voltage is proportional to the amount of pressure applied. Piezoelectric Sensor Circuit is shown in fig.12. A piezoelectric sensor internal circuit is given above. The resistance Ri is the internal resistance or insulator resistance. The inductance is due to the inertia of the sensor. The capacitance Ce is inversely proportional to the elasticity of the sensor material. For the proper response of the sensor, the load and leakage resistance must be large enough so that low frequencies are preserved. A sensor can be called a pressure transducer in an electrical signal. Sensors are also known as primary transducers.

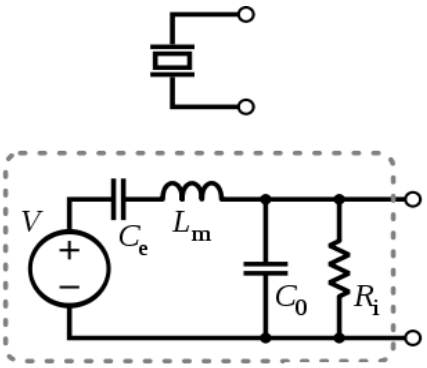

Fig.12Piezoelectric Sensor circuit

The model developed is a step towards an attempt to develop an efficient pedestrian detection system to help reduce the number of accidents that take place due to the recklessness of both the pedestrians walking and the automobile drivers. However, this model comes with a fair share of flaws with it along with the advantages which it carries.

Voltage Detection Sensor Module shown in fig.13.,It is a simple and very useful module that uses a potential divider to reduce any input voltage by a factor of 5. This allows us to use the Analog input pin of a microcontroller to monitor voltages higher than it capable of sensing. For example, with a 0V - 5V Analog input range, you are able to measure a voltage up to 25V. This module also includes convenient screw terminals for easy and secure connections of a wire.

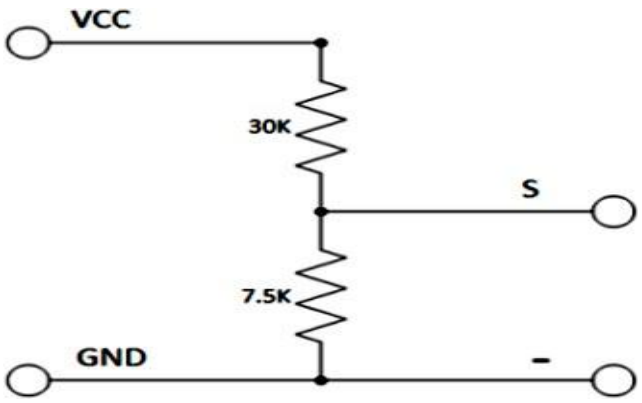

Fig.13 The internal circuit diagram of the Voltage Sensor

The voltage circuit consists of a voltage divider circuit of two resistors in which R1 is 30K and R2 is 7.5K.Using this kind of system in real life will help in mitigating the accidents in places which have a high density of pedestrians walking through daily but with minimal traffic control measures. A pedestrian detection system might be a better alternative to the signboards that are placed in school zones, parks etc. This can also be used in tight corners and turnings which would be blind spots to the drivers. This can also be placed in highways, to detect animals that might sometimes come under the vehicles suddenly causing accidents. We can efficiently keep track of these animals, if any, on the sides of the road and adjust our speeds accordingly so that the damage is minimized in worst case scenarios.

4.CONCLUSIONS

The conclusions are drawn from present work as follows.

The range of measurement system is the range is subject to measurement limits. Sensitivity S, Ratio of change in output signal Δy to the signal that caused the change Δx. $S = \Delta y/\Delta x$. Reliability is the accounts to the sensors ability to keep characteristics in certain limits under set operational conditions. These sensors contain as Impedance value $\leq 500\Omega$. These sensors generally operate in a temperature range of approximately -20°C to +60°C. These sensors are to be kept at a temperature between -30°C to +70°C to prevent them from degradation. These sensors have very low soldering temperature. Strain sensitivity of a piezoelectric sensor is 5V/με. Due to its high flexibility Quartz is the most preferred material as a piezoelectric sensor. Piezoelectric sensors are used for shock detection. Active piezoelectric sensors are used for thickness gauge, flow sensor. Passive piezoelectric sensors are used microphones, accelerometer, musical pickups etc. The roads are the most important public spaces in cities and pedestrians are its largest users, but less than 30% of urban roads in India have footpaths, according to a study. According to Indian Motor Vehicle Act (1998),

it is the duty of the driver to slow down when approaching a pedestrian crossing. Thus, it becomes essential for the drivers to follow the rules and for the pedestrians to not to space out and keep presence of mind while crossing the road. Finally the proposed model would greatly assist the drivers in this regard.

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