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Explosion Intensity Measurement using Piezo Element

Aakash Bansal[1], Ayush Girdhar[2], Kshitij Tomar[3], Shivam Sehgal[4]

[1,2,3,4]Student, Maharaja Surajmal Institute of Technology, G. G. S. I. P. University, New Delhi, India

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Abstract – *With the advancing technology, there has been disputes between nations leading to development of weapons and explosives. More and more budget is being allocated for the warfare and development of arms and ammunition. In recent years, explosive based terrorism has grown enormously because explosive based weapons are simple, easy to develop and deploy and can cause excessive damage. With the development of explosives, it is also important to measure the intensity of the bombs to calculate the potential damage that can be caused by the bombs. Measuring the intensity of a bomb has always been a challenging task. There are many techniques proposed in literature for the measurement of the intensity of explosives, but either these proposed devices are costly or are available only for military grade. The proposed paper describes an easy way to detect the explosive bombs.*

Key Words: Piezoelectric Application, Explosive Detection, Vibration Measurement

1.INTRODUCTION

There have been regular disputes among the nations on different matters leading to warfare. Every nation keeps on increasing the budget for warfare, manufacturing arms and ammunition and research in explosives development.

In doing so, as the science and technology is progressing, and the world is growing at an exponential rate, there is a constant development in the ammunition and upgradation of presently available to improve their efficiency and to support countries and their armies to make them more and more powerful to withstand the situations such as emergencies or wars.

With the changing time, there has been development in more and more furious explosives including atomic bombs, dynamites, nuclear explosives, etc. As the countries, governments, researchers and scientists continue to develop more advanced explosives with time, measurement of their effectiveness, feasibility, strength and working is also an important parameter to consider.

There is always the need of a system which can check the intensity of these bombs and explosives so that the intensity can be measured and the potential damage can be evaluated. Also, if needed, the strength of the explosive can be improved within time.

Bombs and explosives are not only used for warfare, but also used for many industrial purposes such as mining, construction, clearing of mountains and rocks for building industries, roadways, railways and for the development of the area. Besides, explosives are also used for the demolishment of unused or illegal buildings to make use of the vacant space for some other purpose.

Considering the applications of explosives and bombs outside the domain of war, if the explosion is not limited or isn't being controlled properly, it can lead to collateral heavy damage in and/or around the city. Hence, knowing the intensity of a bomb is a much important task before it is approved for the industrial use.

For measuring the intensity of bombs, there have been many techniques proposed in literature earlier by many engineers and researchers. Some of the techniques involve the use of high bandwidth fibre optic pressure sensor, study of blast waves, etc.

All such proposed works involve expensive instruments and techniques and a large amount of time to work with. For optimum sensitivity in explosive intensity measure involves collecting air and particulate samples from the suspected radial area of blasts, they are analysed for explosives and characterize the properties of the soil. But the study of soil and particulates involve a large amount of time and expensive instrumentation for perfected results. The presented paper proposes an approach for the design of an explosion intensity measurement device using its vibrations on explosion.

When explosive bombs explode, the vibrations are sent in all directions which are directly proportional to the intensity of the blast. So, if the device is capable enough to measure the speed of vibrations and their presence, it can actually measure the intensity of the bomb. This can be done using a knock sensor or a piezo element placed a distance apart, it can measure the time gap in vibrations at both the sensors.

To achieve the same, the device is capable enough to calculate the strength at two points, find the time difference between the vibrations, calculate the intensity and help us observe the decrease in strength.

The paper describes the details about the measurement of intensity of bomb explosion using these vibrations. The paper further is divided into multiple sections. The first section describes the different components used, followed by the proposed algorithm in the next section. The last section describes the implementation of the device, experimental results and conclusion with possible future scope.

2. COMPONENTS OF THE DEVICE

1.1 Piezo Element

Piezo Elements are generally used to detect vibrations or knock (and hence are also popularly known as the knock sensors). It is a device that uses piezoelectric effect to measure changes in pressure, accelerometer, temperature, stain or force by converting them to electrical energy.

Piezo elements or piezoelectric sensors are versatile tool for the measurement of various processes. They are used for quality assurance, process control, and for research and development purpose in many industries.

Fig. 1: Piezo Element Disc

Piezoelectricity is the electric charge that accumulates in certain solid materials such as crystals or ceramics in response to applied mechanical stress. The word piezoelectricity means electricity from pressure. The piezoelectric effect is understood as the linear electromechanical interaction between the mechanical and the electrical state in crystalline materials with no inversion symmetry.

Piezo Elements are extremely thin and lightweight sensors for higher accuracy and better results for the measurement of different processes.

1.2 AVR ATMega328P

AVR ATMega328P is a 32 pin low power CMOS 8-bit microcontroller based on the AVR enhanced Reduced Instruction Set Computer (RISC). By executing powerful instructions in a single clock cycle, it can achieve a throughput of 1 million instructions per second per MHz. This empowers system designers to optimize the device for power consumption versus processing speed. It has an inbuilt 32 KB Flash, 1 KB EEPROM, 2 KB of internal SRAM.

1.3 Keypad Matrix

It is a combination of switches arranged in rows and columns for decreasing the number of pins to control them, reduce connections and improve efficiency. When the key is pressed, corresponding circuit gets completed and the data is sent.

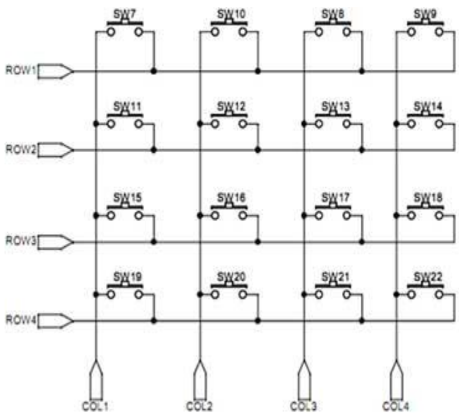

Fig. 2: Keypad Matrix Circuit

The horizontal pins are switched very fast and the output is tested through the vertical axis pins. While switching, if the power was transmitted through the second pin, and the power was detected from third horizontal pin, the pressed key is the third key in the second row.

1.4 16x2 Alphanumeric LCD

16x2 LCD or Liquid Crystal Display is an alphanumeric display with 16 columns and 2 rows of 7x8 microdots that are being controlled by the polarization of crystals inside. It is capable of displaying all ASCII defined characters on the 7x8 microdot display.

Alphanumeric displays are used in a wide range of applications including palmtop computers, photocopiers, point of scale terminals, medical instruments, elevators, etc. It has one command and one data register. The command register is used to define the commands for the LCD such as clearing the screen, defining the location of cursor, etc. The data register stores the data that is sent to it for display on the screen. The data can be transmitted using 8 or 4 bus architecture. In this case, a 4 bus architecture is used since it uses lesser pins and is easy to interface, and despite of the fact that it is slow, the speed will not affect the processing in this application.

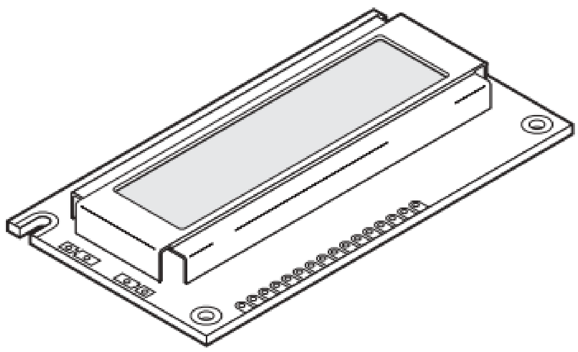

Fig. 3: 16x2 Alphanumeric LCD

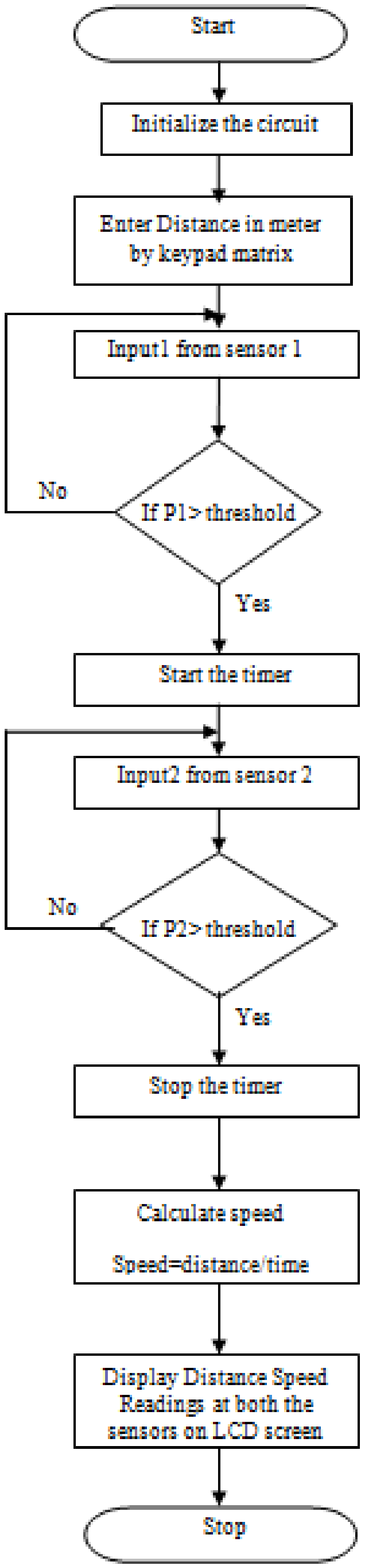

Fig. 4: Flow Chart

2. PROPOSED ALGORITHM

The proposed device is a bomb intensity measurement unit which senses the vibrations in the ground to detect and measure the intensity because after the explosion of the bomb, these vibrations travel through the ground in all the directions and are directly proportional to its intensity. Hence, we use the speed of the vibration travelling between the two sensors and is being measured in this proposed algorithm as a parameter to measure the intensity of the explosion.

As the device is initialized, the user needs to feed the distance between the two piezo elements. For a much accurate result, both of the piezo elements can be kept at a fixed distance using an insulated rod to prevent any kind of disturbance.

As the vibrations travel through the ground, they are sensed by the piezo element which measures the intensity of vibration and the data is fed to a controller. If the received data is above a fixed threshold limit, it is accepted by the controller, and a timer is initiated to note down the time taken by the second sensor to detect the reception of vibrations.

In case this data received by any of the two piezo elements is less than a threshold value, the data is discarded by the controller. The speed of the vibrations can be measured using the basic theorem that specifies the speed is equal to the distance per unit time.

Distance in this case is manually entered by the user or is known earlier because of the fixed gap between the two piezo elements. The time required for the calculation is the time between the first sensor receives the vibration and the time when the second sensor receives the signal, and hence the speed of vibration is calculated.

On the LCD screen, the speed of the vibrations or the intensity of the bomb or explosive calculated using the vibrations is displayed and the same can be used for further analysis like fall of intensity as the distance increases, extent of damage, etc.

3. OBSERVATIONS

To test the system, two different type of crackers were used, one with low impact and the other with a moderate impact. The distance between the two piezo element was varied for the two different crackers from 5 centimeters to 40 centimeters.

Following are the observations made from the same,

TABLE I
OBSERVATIONS

Distance	Cracker Type	Measured Value			
		Test 1	Test 2	Test 3	Average
10 cm	Light	0.15	0.17	0.2	0.17
	Moderate	0.70	0.52	0.64	0.62
20 cm	Light	0.08	0.1	0.07	0.083
	Moderate	0.31	0.35	0.36	0.34
30 cm	Light	0.04	0.09	0.04	0.057
	Moderate	0.25	0.23	0.27	0.25
40 cm	Light	0	0	0.01	0.003
	Moderate	0.07	0.08	0.07	0.073

From the above observations, it can be observed that as we increase the distance, the readings reduce, and in case of 40 cm it starts diminishing for the light cracker, showing its limitation that it cannot exceed a range of 40 centimeters. Though in case of the moderate explosive crackers, they can exceed a range of 40 centimeters and it may exceed the range of 40 centimeters, up to 50 centimeters.

From such observations, it can be inferred that a relation can be established between the range of the explosion and the speed of the vibration travelling between the two points.

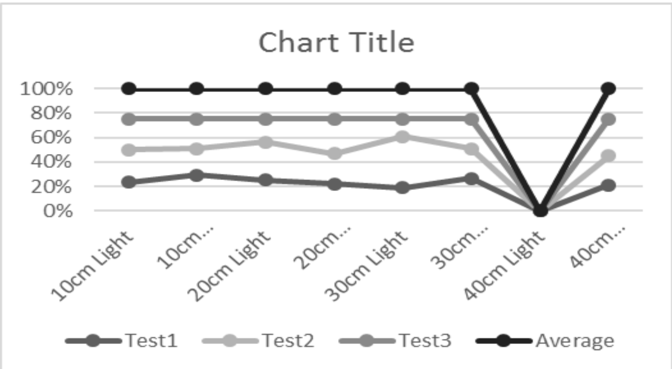

Fig. 5: Graph Representation of Observations

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