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# Use Of Human Ergonomics In Power Harnessing

Anirudhdha C, Dharmambal V, Dr. Nisha Kcr, Ramesh Nayak B, Ganesh M S, Siddarth S Metri

*(Data Analyst, KPMG GDC, Bangalore, India*
*(Senior Assistant Professor, ECE, New Horizon College of Engineering, Bangalore, India*
*(Professor, ECE, New Horizon College of Engineering, Bangalore, India*
*(Associate Professor, IEM, BMS College of Engineering, Bangalore, India*
*(UG Alumni, IEM, BMS College of Engineering, Bangalore, India )*
*(UG Alumni, IEM, BMS College of Engineering, Bangalore, India*
*Corresponding Author: Anirudhdha C*

**ABSTRACT**
This paper emphasizes the use of human ergonomics to harness the energy from energy generators such as piezoelectric films placed in chairs and desks where humans would apply certain amount of pressure while carrying out their work. The pressure applied on the film will help in generating a signal of very low magnitude and these signals are further processed to run various applications. The placement of the piezo films plays a vital role and is therefore thoroughly analyzed with respect to ergonomics.
**Keywords –** Anisotropic, Energy harvesting, Ergonomics, Harnessing, Level shifter, Piezo electric film

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## I. INTRODUCTION

Ergonomics is defined as "The technology concerned with the design, manufacture, and arrangement of products and environments to be safe, healthy, and comfortable for human beings". Ergonomics is basically derived from Greek where "ergon", meaning work, and "nomoi", meaning natural laws. Ergonomics has made great contributions in industrial design, anthropometry and physiology. Ergonomics basically deals with the science behind the 'work'. Ergonomics is usually thought of in product field but it also plays an important role in design of services and processes. The main factors that come into play in ergonomics are comfort level and efficiency. Comfort is one of the main factors of ergonomics. In the human-machine interface, comfort is the first aspect that is seen. A physical pleasing experience has to be there for the product. The mental aspect of comfort in the human-machine interface is found in feedback. The operation of a product depends on how comfortable the device is for operation. Efficiency is nothing but making the work easier such that the final output for the same input is more. In designing a desk many factors including ergonomic factors are very important. Any miscalculations during the design stage can influence a lot in the comfort and efficiency of the final product. If the design is improper it may lead to problems like headaches or eyestrain, neck or back pain. It can help prevent tendon problems, which are linked to tasks that are repetitive.

## II. TYPES OF HUMAN INTERACTIONS WITH KEY OBJECTS

A simple desk setup with all the electricity generating spots is shown in Fig.1 . It explains the pressure points like the wrist support, arm rest, seat of the chair, foot rest, back rest that are available for power generation. Suitable pressure points are found by studying various aspects of ergonomics to generate electricity for multiple applications.

A comfortable workspace can help a person feel the best. If a person sits behind a desk for hours at a time, we are not doomed to a career of neck and back pain or sore wrists and fingers. Proper office ergonomics- including correct chair height, adequate equipment spacing and good desk posture can help us stay comfortable at work[1].

Chair: A chair that supports the spinal curves is always chosen. The height of the chair is adjusted so that the person's feet rest flat on the floor or on a footrest and person's thighs are parallel to the floor. The armrests are adjusted so that the arms gently rest on them along with the shoulders relaxed. Key objects are placed such as the telephone, stapler or printed materials close to the body to minimize reaching. The person has to stand up to reach anything that can't be comfortably reached while sitting[2].

Telephone: If a person frequently talks on the phone and types or writes at the same time, the phone should placed on speaker or a headset needs to be used rather than cradling the phone between the head and neck.

Footrest: If the chair is too high to rest the feet flat on the floor or if the height of the desk requires the person to raise the height of the chair, a footrest should be used. If a footrest is not available, a small stool or a stack of sturdy books are used instead.

Table: Under the table, it is made sure that there is clearance for the knees, thighs and feet. If the table is too low and can't be adjusted, sturdy boards or blocks should be placed under the table's legs. If the table is too high and can't be adjusted, the chair needs to be raised. A footrest should be used to support the feet as needed. If the table has a hard edge, the edges are padded or a wrist rest is used[3].


**Fig.1** Ergonomics in an office workspace

**Fig.2** Aspects of weight distribution

## III. PIEZO FILM INSTALLATION

The piezo film can be installed in various comfortable locations in a workspace taking into consideration the aspects of[14] weight distribution as shown in Fig.2

Footrest: The footrest should be located below the table in such a way that the person sitting on the chair can comfortably rest their legs on the footrest. By doing so, the person is in their comfortable position. The piezo coin should be installed on the exact location on the footrest with the help of adhesives as shown in Figs 3.1 & 3.2. By doing so, a person can be comfortable and at the same time generate electricity.

**Fig.3.1** Footrest setup

**Fig.3.2** Footrest setup

Backrest: A chair is chosen such that it supports the spinal curves. The height of the chair is adjusted so that our feet rest flat on the floor or on

the footrest. The thighs are therefore parallel to the ground. The piezo can be excited by placing the piezo coin at these locations on the chair with the help of adhesives as shown in Fig. 4.

**Fig.4** Backrest

Table: A table of suitable height as shown in Fig. 5, 6 and 7 should be chosen such that the person can comfortably write, work and perform other basic functions. Piezo films can be installed in critical points such as on table tops and in cup holders, which thereby facilitates the generation of electricity while performing the basic functions.

**Fig.5** Table

**Fig.6** Cup holder

**Fig.7** Cup holder setup

**Armrest:** The height of the armrest is adjusted so that the person can comfortably rest his arms while working. A piezo film can be attached on the armrest to generate electricity. Thereby, the armrest not only solves the purpose, at the same time generates electricity.

**Under thigh support:** A chair is chosen such that it supports the spinal curves. The height of the chair is adjusted so that our feet rest flat on the floor or on the footrest. The thighs are therefore parallel to the ground. The piezo can be excited by placing the piezo coin at these locations on the chair with the help of adhesives as shown in Fig.8.

**Fig.8** Under Thigh Support

## IV. PIEZO FILM INTRODUCTION

One of the renewable forms of energy is piezoelectricity. Piezoelectricity is the[4] phenomenon that deals with the generation of electric potential when pressure [7]is applied. The word piezo comes from the Greek word piezein, meaning to press or squeeze. It was found that there was a change in the dimensions of the material when subjected to an electric field. Similarly when these materials were subjected to mechanical pressure, electrical potential was[9] generated on the faces of the crystals. When the crystals are compressed, it forces negative ions within each unit cell of the crystal to rearrange itself. This leads to the polarization of the unit cells and on a larger scale, the appearance of an electrical potential difference on the faces of the crystals. If an isolated crystal is used, then the polarization shows itself as a voltage across the crystal.

Piezo electric materials are anisotropic[4] in nature. That is their electric and mechanical responses differ depending upon the axis of the applied electric field, mechanical stress or strain.

The piezoelectric effects are found in several types of crystals and also in some ceramics and plastic materials. The most widely used piezo electric material is provskite structured Pb (Lead), which is extensively[16] used in various types of electromechanical sensors, actuators, and energy generators.

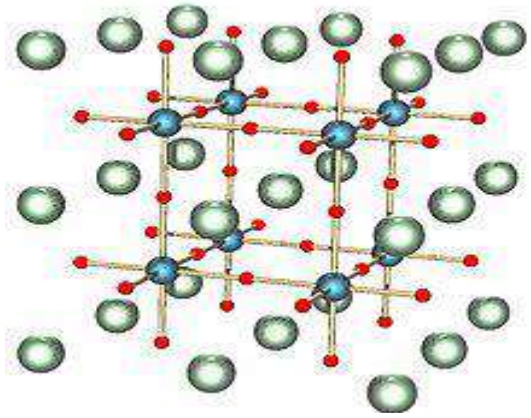

**Fig. 9** Anisotropic structure

A perovskite is any material with the same type of crystal structure as calcium titanium oxide (CaTiO3), known as the perovskite structure, or XIIA2+VIB4+X2−3 with t he oxygen in the face centers.

Harnessing[10] energy from such piezo based resources and making them readily available to the end users is a major challenge faced by designers today. Mechanical strains generated by the piezoelectric effect are relatively low[13] and must be amplified for practical purposes. Many people have been using piezoelectric materials as a source of electricity. But the major drawback of the piezoelectric materials is the low output obtained from the crystal.

Jacques and Pierre Curie discovered the piezoelectric effect in 1880 during their study on generation of electricity by the effect of pressure in crystals such as quartz. The piezo material upholds both ‘the direct piezoelectric effect’ and ‘the converse piezoelectric effect’. In the first case the material generates electricity when subjected to mechanical stress[14] and in the latter case the material undergoes stress or strain when electric potential is applied.

Piezo materials are found to be very light and flexible. It’s a tough engineering plastic, which is available in a wide range of thicknesses and areas. A piezo film working[8] as a transducer has the following specifications:

1. Piezo material has wider frequency ranging from 0.001 Hz to 109 Hz
2. It has a dynamic range from 10-8 to 106 Mbar
3. It has low acoustic impedance
4. It has elastic compliance which is high
5. Has a higher voltage output for the same input force
6. Has high dielectric strength
7. High mechanical strength and impact resistance ranging between 10000 – 100000 bar

8. Has high stability by resisting moisture, chemicals, oxidants and intense ultraviolet and nuclear radiation
9. It can be fabricated into unusual designs
10. It can be glued with the help of commercial adhesives

Piezo film does have some limitations for certain applications. It makes a relatively[11] weak electromechanical transmitter when compared to ceramics, particularly at resonance and in low frequency applications. Therefore after looking at the piezoelectric effect and its material properties, it can be used as [6][5]power generator.

A piezoelectric material picks up the ambient vibration[7] or the pressure applied on it and produces electricity. The output of a piezo film on application of an external force ranges between microvolts to hundred milli volts and hence signals conditioning is [13]required in order to power an application.

## V. MODELLING OF PIEZO FILM

Considering all the key characteristics of a piezo material, a circuit is designed to obtain a sinusoidal waveform of 50Hz. The peak-to-peak amplitude of the signal which is fed to further signal conditioning stages is assumed with reference to the pre-defined dimensions of the piezo film. Piezo film can be modeled[12] as a Voltage source V1 in series with a capacitance C1 as shown in the Fig. 10. V1 and C1 shown are of piezo film components. The voltage source is proportional to the applied stimulus like pressure, force, strain etc.

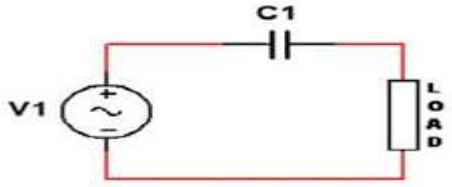


**Fig. 10** Model of piezo film

### PROPOSED PIEZO BASED SYSTEM

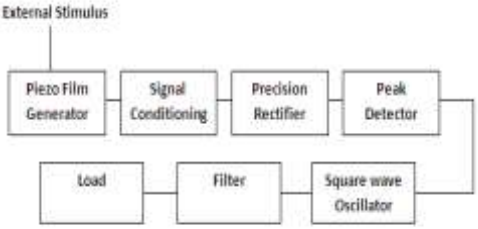


**Fig. 11** Block diagram of proposed system

Fig. 11 shows the block diagram of a[16] proposed piezo based system. In the above proposed system the piezo film is excited with the help of an external stimulus. This external stimulus can be caused either through pressure, force or strain etc. This external disturbance can be by hand pressure or a ram type of mechanism, which continuously keeps applying force on the piezo film. This external disturbance excites the piezo film thereby generating low current, low voltage output. The signal so obtained here is sent for conditioning through different signal conditioning stages using precision operational amplifiers, precision rectifiers, current boosters, square wave oscillators and harmonic filters. The signal thus obtained after conditioning is processed further with the help of a step up transformer to power up different applications.

## VI. STAGES OF THE SYSTEM

### 6.1 STAGE 1 : SIGNAL CONDITIONING

The piezo film is successfully excited using an external stimulus. From the obtained ambient vibrations, only the voltage generated during the process is taken as a signal source to the entire system. Hence the piezo film is operated in voltage mode. The received output is then conditioned with the help of precision amplifiers. An amplifier is an electronic circuit, which can amplify the amplitude of a signal. A precision amplifier is used for high precision signal processing. These operational amplifiers needs low input bias current to process the output generated from the piezo film. Thereby the output signal is amplified and[13] conditioned by selecting the suitable voltage gain.

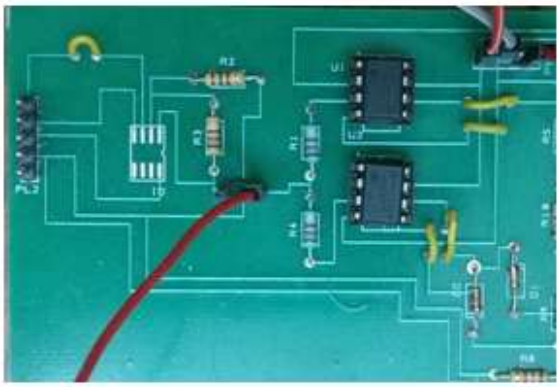

**Fig. 12** Signal conditioning circuit

### 6.2 STAGE 2 : PRECISION RECTIFIER

The amplified output is then rectified with the help of a precision rectifier. A rectifier is an electronic circuit that converts an alternating signal into pulsating direct current by allowing a unidirectional flow of current through the load. A precision rectifier consists of operational amplifiers, diodes and resistors. Compared to the conventional

rectifier, a precision rectifier has an advantage to rectify any range of frequency signals excluding the diode drop. The purpose of rectification is to produce a DC voltage, which is used as a supply voltage in order to operate a square wave oscillator operating at 50 Hz. Thereby the amplified alternating signal is converted into direct signal by the process of rectification.

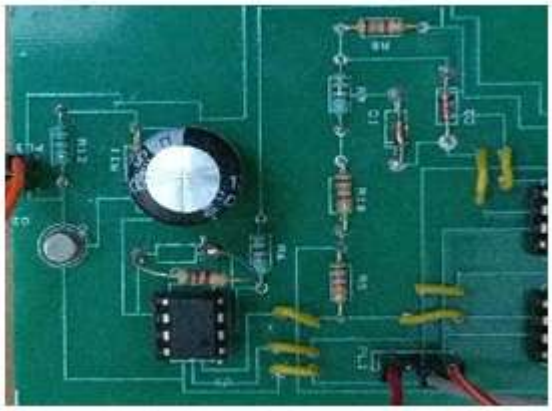

**Fig. 13** Precision rectifier circuit

### 6.3 STAGE 3 : PEAK DETECTOR AND CURRENT BOOSTER

The pulsating DC obtained from the precision rectifier is peak detected by the RC network and is given to the current booster. The current booster is basically an emitter follower (Common collector configuration), which can magnify the current level of the signal without altering the magnitude of the signal. The purpose of the current booster is to provide sufficient current sourcing capacity to the square wave oscillator. Hence the output of the current booster is used as a supply voltage for the square wave oscillator.

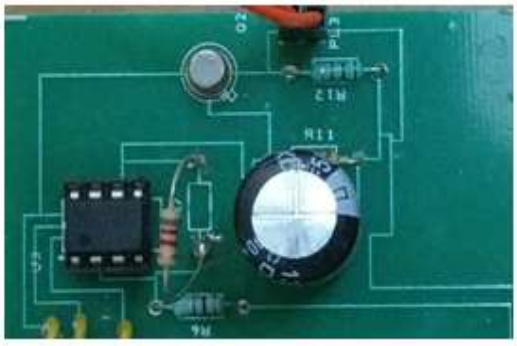

**Fig. 14** Current booster circuit

### 6.4 STAGE 4 : SQUARE WAVE OSCILLATOR

The oscillator is designed to generate 50Hz square wave signal. The oscillator uses NE555, operated as astable multivibrator (free running mode) generating square wave signal at 50 Hz. An oscillator is an electronic circuit that generates oscillatory electric currents or voltages by non-mechanical means. An oscillator can either generate sinusoidal or non-sinusoidal waveforms of very high frequencies from very low frequencies. The square wave signal generated at the output of NE555 swings between 0V and the supply voltage with equal On and Off period. the oscillating signal is made to oscillate above and below the zero reference with the help of a level shifter.

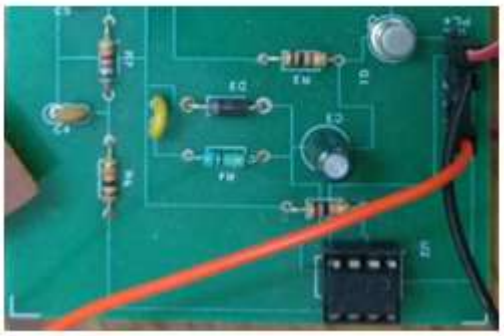

**Fig. 15** Oscillator circuit

### 6.5 STAGE 5 : FILTER

The square wave signal, which is the output of the square wave oscillator, consists of a fundamental component and harmonics of the fundamental component. Various stages of[17] harmonic suppression filter are used in order to suppress the 3rd, 7th, 9th… harmonics to obtain sinusoidal fundamental sinusoidal signal of 50 Hz.

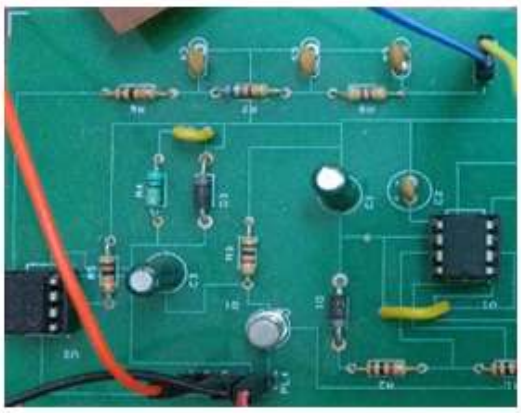

**Fig. 16** Filter circuit

### 6.6 STAGE 6 : DRIVER STAGE

The driver stage consists of 'Complementary symmetry pairs' connected[18] in cascaded configuration. This cascaded configuration is known as 'Darlington pair'. This arrangement will enable the complete sinusoidal signal to possess sufficient current driving capacity for the load.

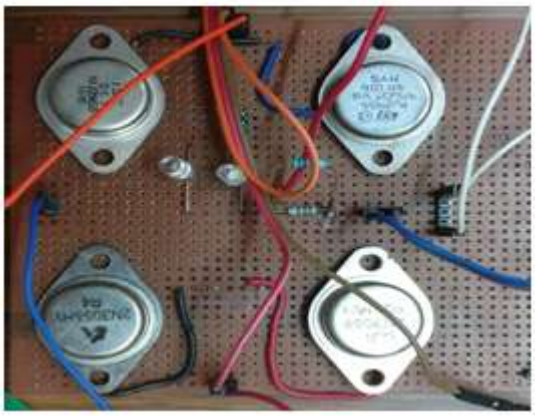

**Fig. 17** Driver circuit

### 6.7 STAGE 7 : STEP UP TRANSFORMER

The transformer is an electrical unit, which provides proper electrical isolation. The output of the driver stage is loaded with the primary of the step up transformer. The purpose of the step up transformer is to boost the secondary voltage to the required level to meet the need of the load.


**Fig. 18** Step up transformer

### 6.8 STAGE 8 : LOAD

The output signal obtained from the transformer is in the form of a sine wave of frequency 50Hz. This output signal obtained is used to run the load.

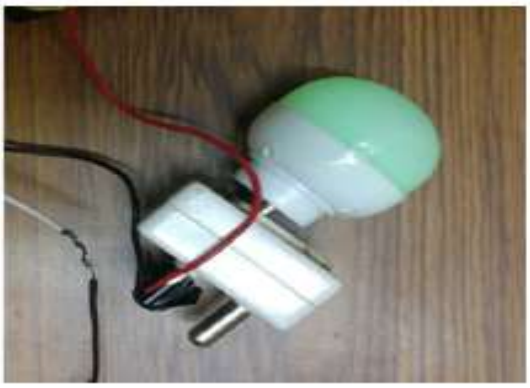

**Fig. 19** Load

## VII. SIMULATED RESULTS

The designed circuit was also simulated using ORCAD Pspice and the following results were obtained. The sinusoidal signal, which is generated from the piezo film, is as shown in the Fig. 20.

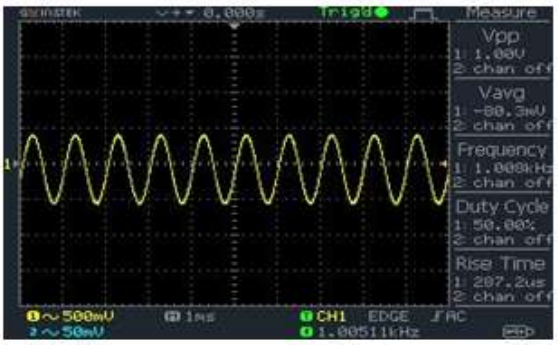


**Fig.20** Output signal of 1V peak to peak

The amplified signal after passing through the signal conditioning circuit is as shown in Fig. 21.

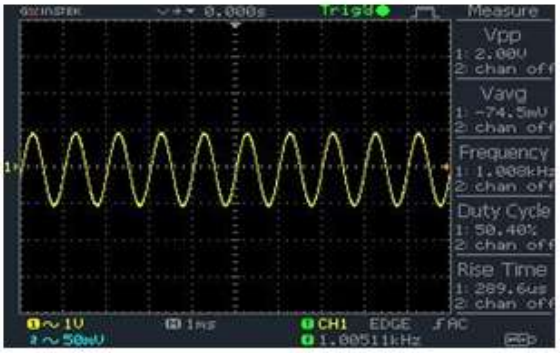


**Fig.21** Output signal after signal conditioning

The rectified output signal of precision rectifier is as shown in Fig. 22.

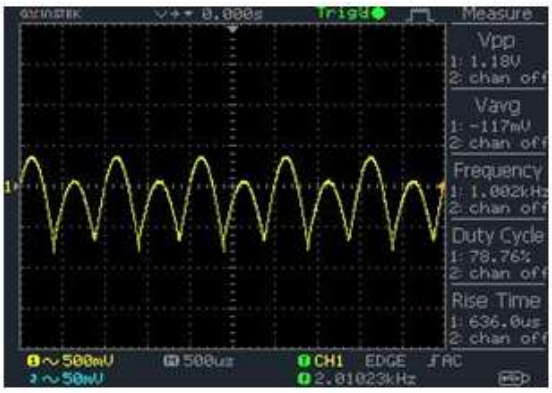


**Fig.22** Output Signal of Precision rectifier

The output signals post peak detection and current boosting is as shown in the Fig. 23.

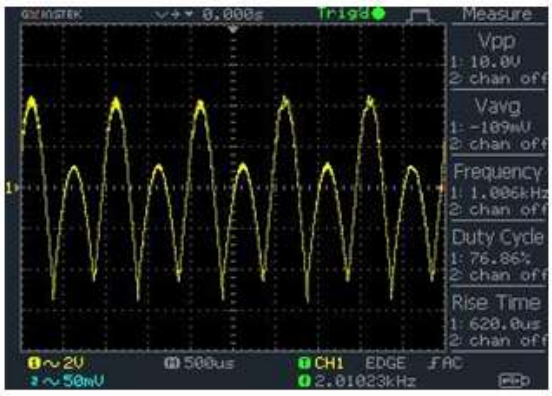


**Fig.23** Output signal after current boosting

The output of square wave oscillator is as shown in the Fig.24.

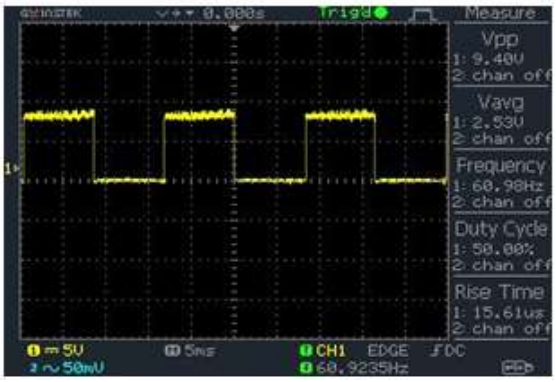


**Fig.24** Output signal of square wave oscillator

The output signal after passing through the filter stage is as shown in Fig.25.

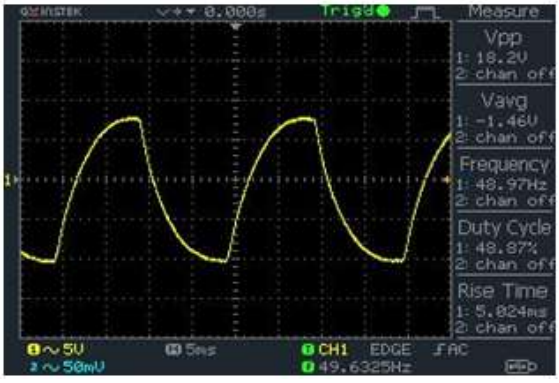


**Fig.25** Outut signal after seventh harmonic suppression

## VIII. EXPERIMENTAL RESULTS

Experimental results obtained using a single piezo (A circular piezo film of diameter 2.5cm):
Current: 31mA (I)
Voltage: 6.15v (Vrms)
Power: (Vrms * I ) …(1)
$31 * 6.15 * 10^{-3} = 0.19W$

Therefore the total power obtained while using a single piezo is 0.19W.

## IX. CONCLUSION

New product development brings together various technologies, techniques, concepts and ideas into reality. It is a subject of great interest to engineers as it helps in making our livelihood easier and more efficient.

The major aim was to generate electrical energy from the pressure applied by various physical movements performed by humans. Therefore a suitable system was developed. It can be inferred that energy can be made available to the load by an external stimulus, which is a renewable form of energy. It is the most economical, affordable energy solution to common people as the current consumed by the designed circuit is very minimal.

Therefore, through this process, electricity was generated from a single piezo film which is used to run a simple LED bulb. The circuit was optimized thereby to reduce the human pressure required to excite the piezo film.

## X. FUTURE SCOPE OF WORK

The designed circuit has a limited current capacity due to the minimum number of usage of piezo films and fewer possible excitations initiated by humans considering the various aspects of human ergonomics. This work can be further extended in order to obtain higher output capacity with zero energy sources to power up electronic circuits which are essentially needed to process the signals generated by piezo films by nonconventional energy sources like PV array and with the optimal use of human power.

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