

# A New Frontier of Alternate Source of Energy: 'Human Energy Harvesting System' for a Wearable UV Exposure Meter

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## Abstract

Rapid evolution in the domains of wearable devices and instrumentation have brought about a paradigm shift in the design and applications of sensing devices. Such has been the impact of these advances that the devices have pushed the frontiers of portability w.r.t. devices to an upcoming class of devices called wearable devices. Wearable devices are being used to gather physiological information, motion based information and weather related information centered around the wearer.

This research is aimed at extending state of the art pertaining to the measurement of exposure to the UV (Ultraviolet) radiation which, beyond certain limits, is harmful for human skin. Following an extensive research on the concepts and technologies used for designing UV exposure monitors, a unique wearable UV exposure meter has been designed. It is not only an energy efficient wearable device but uses a new modality of energy's source. The wearable UV exposure meter uses a mechanism that sources its energy from an inbuilt human energy harvesting system. This research presents design and development aspects of this wearable UV exposure meter that also guides the wearer to use an appropriate Sun Protection Factor (SPF) protection scheme.

## Keywords

Ultraviolet, Energy Harvesting, Wearable, SPF

## I. Introduction

Sunlight plays a major role in our life and, mostly in the making of Vitamin D, that essential for our health. A tan is the most common effect from a potential deadly solar source i.e. UV or ultraviolet rays. The sun emits different kinds of electromagnetic radiation, out of which 99% is in the form of visible light, UV rays, and infrared rays. UV wavelength i.e. 400 nm to 100 nm, is shorter than visible light i.e. 400 nm to 700 nm, and longer than X-rays i.e. 0.01 to 10 nm. Other than the sun there are some more devices that emit UV like bactericidal black light lamps, metal halide lamps, mercury lamps, plasma torches etc. [1]. This research presents the design of wearable UV exposure meter, which is free from any type of app based device.

UV damages all types of human skin be it dark skin or fair skin and all other shades in between. The UV light works as same as any other light, it absorbs and reflected. Our DNA gets corrupted through the UV radiation and cause skin cancer. Sunburns are also called radiation burns which may occur from over exposure to the UV radiation. All sun exposures result in UV light impacting the skin. It's everywhere in snow, in pool, etc. light skin people are more prone to the skin cancers because they have to make up for not having melanin and it is for this reason perhaps the cancer strikes less on the darker skin [2]. Therefore, you can use sunscreen which contain organic and inorganic chemical to block the UV rays that cause skin cancers, sun burns or sun tans. The

titanium dioxide and zinc oxide nano particles in the sunscreen react with UV rays and creating hydrogen peroxide toxins. Though it is better to wear sunscreens when you go outside.

## II. Types of UV rays

Quite like color in the visible spectrum, there is a color of UV rays also and in it is divided into 3 bands:-

**UV A-** It is closest to the visible light and wavelength is given as 315 nm to 400 nm. It is the long and not absorbed by the ozone layer. UVA ray is also known as black light, this layer goes deeper inside the lower layer of the skin that breaks the collagen by increasing the enzymes and ruptures elastic fibers that give the youth tight and healthy skin. Tanning boosters are also a source of 90 % of the UVA rays.

**UV B-** It is a medium wave and mostly absorbed by the ozone layer and wavelength is given as 280 nm to 315 nm. UVB rays go superficial into the skin, when you go outside that damage the cells that make up our skin keratinosis.

**UV C-** It is short wave and blocked almost completely by ozone layer and wavelength is given as 100 nm to 280 nm.

UV rays could not filter out by the clouds or pollution. UV rays travel through sand, mirrors, water and snow, as all the rays get reflected back.

There is both harmful and beneficial side of UV exposure. UV index meter indicates about the harmful effects of sun rays. In this research, we introduce a system that continuously tracks the UV exposure by wearable UV sensor and tell us the different UV index levels and sunscreen's SPF level. A portable and wearable low cost device, has been designed, it also aims to solve the problem of battery charging in an easy and cheap way by using human energy harvesting system.

## III. Previous Work

X. Zhang, W. Xu, et. al. [3] presented a personalized UV monitoring and notification system. Using wearable sensor system could continuously track the UV exposure. It could give a predictive sunburned skin model by visualising the cumulative UV exposure dose.

Thomas Fahrni, Michael Kuhn et. al. [4] introduced a wearable prototype system that track wearer's exposure in real-time. So from this paper we would design a body worn device that does not entirely depend on a smart phone for its functioning. The said low-cost wearable system consists of two parts: (1) A small sensor unit that measures the UV radiation in real time and a Bluetooth module. (2) A smart phone application that gives the real time results.

Peng et al. [5] describes a new type of piezoelectric energy harvesting device that harvests and gives power to an LCD device and LED lamp that is useful in applications of wearable devices.

#### IV. Proposed Algorithm

A. This research is aimed at extending state of the art pertaining to the measurement of exposure to the UV (Ultraviolet) radiation which is significantly harmful for human skin. Following an extensive research on the concepts and technologies used for designing UV exposure monitors, a unique wearable UV exposure meter has been designed. It is not only an energy efficient wearable device but uses a new modality of energy's source. The wearable UV exposure meter uses a mechanism that sources its energy from an inbuilt human energy harvesting system. This system would enhance public awareness and alert people when exposed to UV radiation so that they can protect themselves and adopt protective measures.

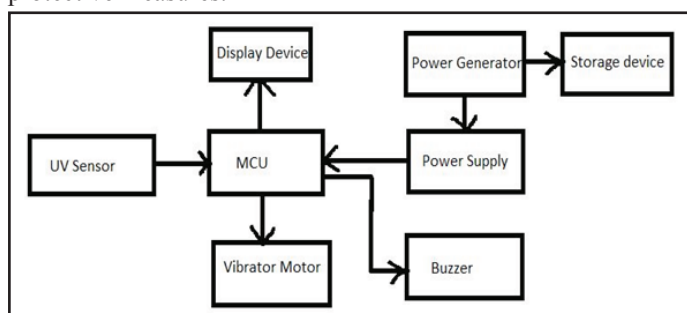


Fig. 1: Basic Diagram of Proposed System

The fig. 1 shows the basic block diagram of system, in which microcontroller is the main controller part which controls all the other supporting circuitry i.e. UV sensor, display device, vibrator motor and buzzer. And also users don't need to worry about recharging or replacing any batteries, as the device is powered by the human motion. Therefore, to charge a battery we need to make parallel connections of these piezo sensors. Some of the advantage of piezoelectric sensor is given as:

- Piezoelectric sensors are connected in such manner to enhance voltage and current rating of any electric device.
- If we connect the Piezo sensors in series then it enhances the voltage level and if we connect the Piezo sensor in parallel then it enhance the current level for any electronic device or panel.
- It works in both day and night.
- It also generates electricity when wind energy is not present.
- They are easily available and ready to use.
- These sensors have long life, small in size, low noise, and broad frequency range.
- They are cost-effective.

B. In order to achieve the objective that is to sense UV exposure in real time, there is a need to develop a wearable device that tracks the daily UV exposure of an individual. Once activated as shown in fig. 2, the integrated UV sensor measures incoming ultraviolet radiation. An onboard UV index sensor keeps track of the growing exposure. If the measured UV exposure is greater than the true UV index level, than an alarm gets activated and gives an indication through a LED, so that the user can apply the sunscreen according to measured UV index level.

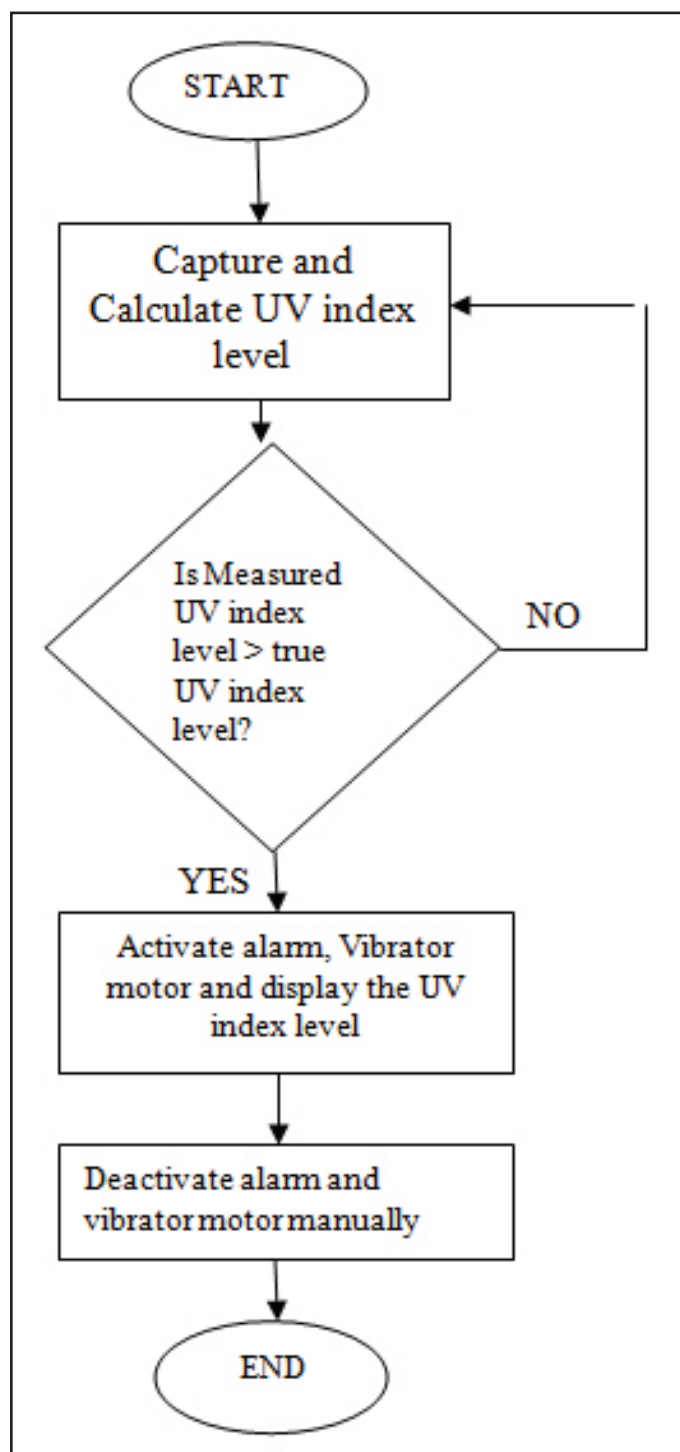


Fig. 2: Methodology of System

#### V. Experiment and Result

A. In fig. 3 shows the results of piezo sensors generating voltage when connecting in parallel. When we pressed the disk, piezoelectric plating work as positive terminal and copper plating as negative terminal but when we released the piezo disk it'll behave as inverse. It showed polarity of material that changes when pressed and released. A piezoelectric material disk generated a voltage in the range of -6.0 V to +6.0 V when mechanical pressure is applied on it. We can make different pairs of piezo sensors in parallel and series both. So that we can increase the current as well as voltage level. Voltages and currents level using different mechanism shown below:-



Fig. 3: Experimental Result of Piezoelectric Sensors

Pressing By Hand = 15.03 volts (2mA)

Walking by Foot = 18.53 volts (5mA)

Running by Foot = 27.89 volts (11mA)[6]

**B.** In fig. 4, a wearable UV exposure meter is shown. In this we use UV index meter to calculate UV and SPF level. A mini vibrator motor alerts the visually impaired person about the SPF level whereas buzzer and LED are used to alert them about UV index level. And fig. 5. shows the final wearable prototype of proposed system.

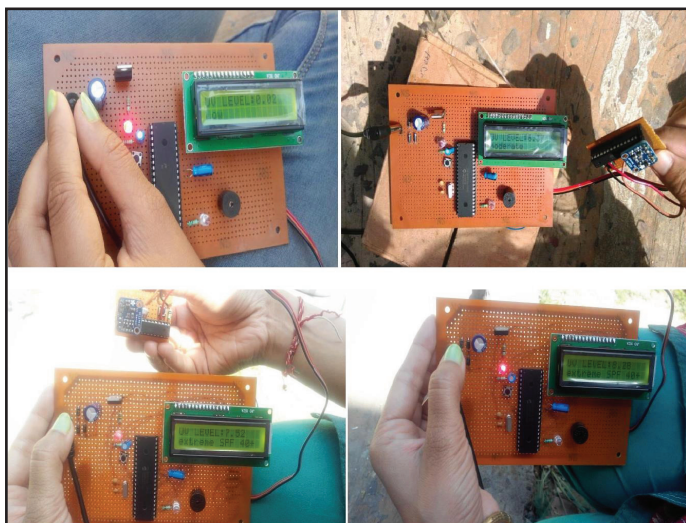


Fig. 4: Experimental results of measuring UV index sensor

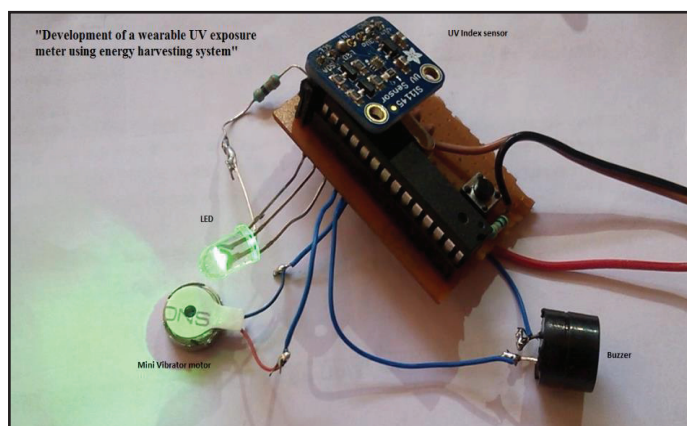


Fig. 5: Prototype of System

## VI. Conclusion

This research is aimed at extending state of the art pertaining to the measurement of exposure to the UV (Ultraviolet) radiation which is significantly harmful for human skin. While designing the system we have faced a problem of discharging of piezo arrays when human is not in motion. For continuous voltage via piezo sensors we may attach spring to the piezo's plate.

The system has microcontroller based charge controller circuitry in it. As per the latest technology development there are some various implementations which can enhance system practicality and productivity:

- Use user's skin profile to calculate UV index level.
- Use user's location to alert.
- Use high efficiency PZT material.
- Use of super capacitor to decrease charging time.

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Neha has done her bachelor of technology degree in Electronics and Communication engineering with first division from Punjab Technical University Jalandhar in year 2011 and currently pursuing her Master of Technology degree in Electronics Product Design & Technology from CDAC, Mohali. Her areas of interests are microcontrollers, Analog and Digital electronics.



Dr. Sanjay Sood's experience spans various geographies. He has travelled to over 20 countries. Dr. Sood has been the founder Director and Head of School at C-DAC School of Advanced Computing in Mauritius. For three years he was a Senate Member of Mauritius University. Dr. Sood has been a Consultant with World Health Organization & World Bank and was an eHealth expert for UN agency for outer space affairs.

Dr. Sood is currently heading Health Informatics at C-DAC Mohali where he is conceptualizing smart health solutions.