

Smart Footstep Power Generation System Using Arduino And Piezoelectric Sensor

Sasikala R¹, Gowsalya K², Jayapriya P³, Mahalakshmi M⁴, Sivaprakash C⁵

¹Assist prof, Dept of Electronics and Communication Engineering

^{2, 3, 4, 5} Dept of Electronics and Communication Engineering

^{1, 2, 3, 4, 5} Nelliandavar Institute of Technology, Pudhupalayam

Abstract- *Smart Street Lighting aims to improve the efficiency of street lights by automating their control as and when needed, without the need for an external power source. Vehicles moving down the road cause vibrations in the piezoelectric material beneath the road due to deformation caused by vehicle passing pressure. Piezoelectricity is an electric charge that builds up in certain solid materials (such as crystals and certain ceramic materials) when torque is applied. Nowadays, most of the existing street light systems are wired which are not only difficult to construct but also have poor flexibility. To overcome IOT technology using a piezoelectric sensor which uses power efficiently by remotely monitoring and controlling the system. This design can save a better amount of electricity compared to street lamps that keep a light during the night for this system power supply is given by a solar panel and piezoelectric transducer placed on the road. When a vehicle is passing on-road then pressure is applied, According to the property of piezoelectric material energy is generated when pressure is applied to it. LDR is a minor component that works on the intensity of light. When the light intensity is increased, LDR resistance increases, and when light intensity is decreased, LDR resistance decreases. The system only turns on street lights when they are needed to maintain a secure and safe traffic environment. Light automatically dims up or down in partial road areas when the street lighting system is computer-controlled.*

Keywords: Piezoelectric Effect, Footstep energy harvesting, Smart energy generation system, Low-power energy harvesting, Renewable micro-energy systems

I. INTRODUCTION

A monolithic lead (Polycrystalline) piezo ceramic is one method of storing electric energy generated. The amount of power that a single piezoelectric material device can generate has been calculated and verified to be significantly less than what is required for most electronics in real-time applications. When determining the best storage method, the time it takes for piezoelectric materials to charge power storage devices must be factored in for the electronics that will be powered. Furthermore, both the piezoelectric material and

the circuit's low-efficiency performance have been identified as critical issues.

1.1 BACKGROUND AND CONTEXT

The global demand for energy has been rising at an unprecedented rate due to rapid industrialization, urbanization, and population growth. According to the International Energy Agency, global electricity consumption is expected to increase by nearly 50% by 2030, with a significant portion dedicated to public infrastructure such as street lighting. Conventional street lighting systems, while essential for public safety and traffic management, operate on a fixed schedule often remaining lit throughout the night regardless of the actual presence of vehicles or pedestrians. This inefficient practice leads to substantial energy wastage, higher carbon emissions, and increased operational costs for municipalities.

1.2 MOTIVATION FOR THE STUDY

The motivation behind this project stems from three core principles of sustainable engineering: **energy conservation, renewable energy harvesting, and intelligent automation.**

Energy Conservation: As a society, we cannot continue to waste electricity on empty streets. The concept of “light on demand” is not only economically sensible but also environmentally responsible. By using LDR sensors to detect ambient light levels and only activating street lights in darkness, the system reduces unnecessary power consumption. Furthermore, by dimming or turning off lights on empty roads (detected indirectly via piezoelectric signals), the system ensures that energy is used only when movement is present.

Renewable Energy Harvesting: Piezoelectric energy harvesting is an emerging field that captures otherwise lost mechanical energy. A single footstep on a piezoelectric tile can generate 2–5 joules of energy. While this may seem small, multiplying this by thousands of footsteps or vehicle passes per day on a busy street can produce a meaningful amount of electricity. When combined with a solar panel, the system

becomes even more robust generating power from sunlight during the day and from mechanical pressure throughout the day and night. This hybrid approach ensures a more continuous power supply.

II. LITERATURE SURVEY

2.1 Smart street light using intensity controller

Smart Street Light is the intelligent control of street lights to solve the problem of late-night street power consumption. At the moment, standard street lights turn on when it gets dark and turn off when it gets bright. This is a massive waste of energy around the world because it is a necessary community service, but the current implementation is inefficient. Traditional street lighting is being replaced with a Light Emitting Diode (LED) street lighting system, which consumes less energy. The goal of this project is to design a street light control system that will reduce energy usage. Light Dependent Resistor (LDR), Infrared Sensor (IR), Battery, and LED are used to create the prototype. The Arduino UNO served as the controller for all of these components. To save energy, the brightness of the lamps is controlled in this project. The lamps dim depending on the speed of detected object motion, such as pedestrians, cyclists, and cars. The level of intensity increases as the speed of the moving object increases. The innovation of street lights for this concept is not the same as traditional street lights, which are controlled by a timer switch or light sensor that turns the lights on and off automatically at sunset and sunrise.

2.2 Automatic brightness adjustment using IoT platform

Smart parking, smart homes, smart roads, smart lighting, and other automation applications are among the IoT's many applications. In today's world of transportation, streetlamps are a must-have for safety and avoiding nighttime accidents. Despite this, no one in today's busy lives tries to turn it off or on when it isn't needed. By reducing manpower and conserving energy, this project provides a solution. The current manual streetlamp system has several flaws, including timing issues, maintenance issues, and lack of connectivity. IoT technology has the potential to solve these issues.

2.3 IoT based solar smart led street lighting system”,

Automation, power consumption, and cost-effectiveness are the current field technologies. With the help of intelligent systems, automation aims to reduce manpower. Because energy sources are limited and the energy consumption is increasing, the use of renewable energy

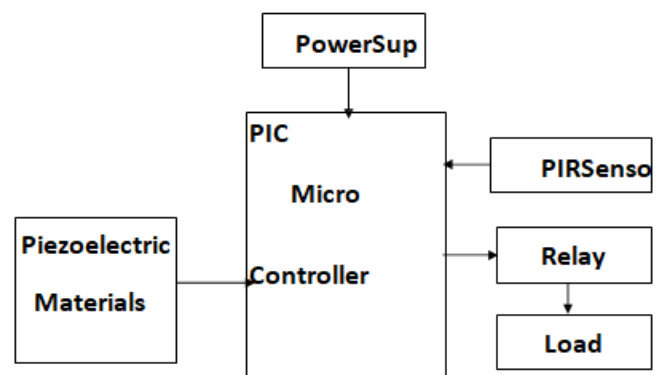
sources is critical. It is possible to meet the high power demand by employing renewable energy. They describe a method for modifying street light illumination with sensors while using the least amount of electrical energy possible. When a person is detected, all nearby street lights turn on at their brightest setting; otherwise, they remain in the dim setting. LED bulbs should be used because they are superior to incandescent bulbs in every way.

2.4 Smart traffic control management system

A period of time is defined by a specific interval of time. However, here, traffic light signals are generated based on the volume of traffic and the time of day. A few IR sensors will be placed away from the highway to monitor traffic density. Depending on the signals produced by the sensors, the timing of traffic signals will be changed. The output of the sensors is fed into a comparator, which virtualizes it. Using a GPS modem, this system can locate nearby ambulance services and hospitals treatment as soon as possible.

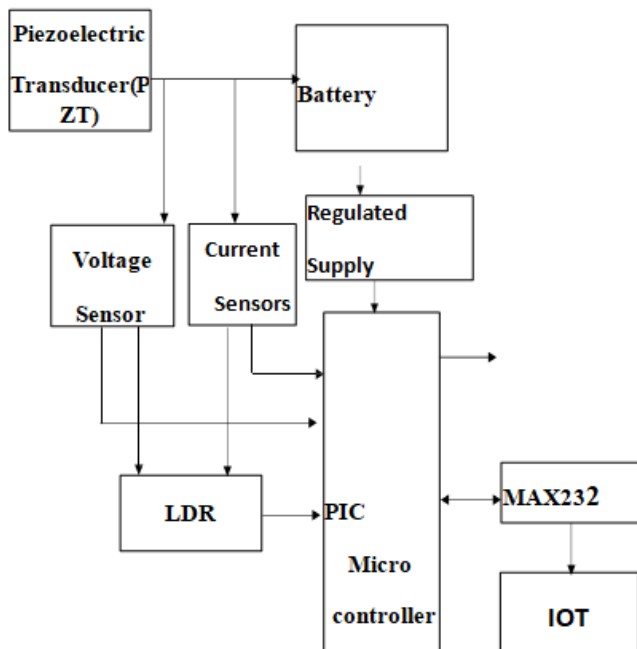
III. EXISTING METHOD

In the existing method of footstep power generation and optimization for street light systems, a footstep power generation system is developed here that uses piezoelectric sensors to generate power through footsteps as a renewable energy source that can be obtained while walking on a specific arrangement, such as stepping foot on piezo tiles. The use of piezoelectric materials to harvest energy from people walking vibrations for generating and accumulating energy is described in this method. The "footstep power generation system's" basic working principle is based on piezoelectric sensors. The electrical energy produced by the pressure is captured by floor sensors and converted to an electrical charge by a piezoelectric transducer when the flooring is engineered with piezoelectric technology. These sensors are positioned in such a way that they produce the highest possible output voltage



IV. PROPOSED SYSTEM

In the proposed method for the efficient storage of produced piezoelectric voltage in a lithium metal hydride battery. In this method, a voltage and current sensor detect the object, and a series of piezoelectric sensors detect the vehicle's pressure and accordingly produce the voltage to store in a battery. A well-designed energy-efficient street light system should permit traffic and pedestrian to travel with great visibility in safety and comfort while reducing cost and energy consumption. This method requires an LDR to detect day or night, in this system put into light the piezoelectric effect in which certain materials can build up an electrical charge from having pressure and strain applied to them. This system is focused on the applications of auto street lights for transportation facilities using that energy. When the roads are engineered with piezoelectric technology, the energy produced by the pressure of moving vehicles is captured by piezo sensors and converted into electrical charge by a Piezoelectric Transducer (PZT), then the energy is stored and used as an energy generation source. This energy source can be used for auto street lighting as a source of roadside power generation units. The power is generated as a result of pressure due to the movement of vehicles on the road to control street lighting on highways and also automate their process.



V. POWER SUPPLY

Because of cost considerations, electrical power is almost exclusively generated, transmitted, and distributed in the form of ac, but most electronic devices and circuits require

a DC supply. Because of this, dry cells and batteries can be used. They are certainly portable and ripple-free, but their voltages are low, they require frequent replacement, and they are expensive compared to traditional dc power supplies. Almost all electronic equipment today includes a circuit that converts AC power to DC power. DC power supply is the component of equipment that converts chemical energy to electrical energy. A power transformer is usually found at the power supply's input. From the block diagram, the basic power supply is constituted by four elements a transformer, a rectifier, a filter, and a regulator put together.

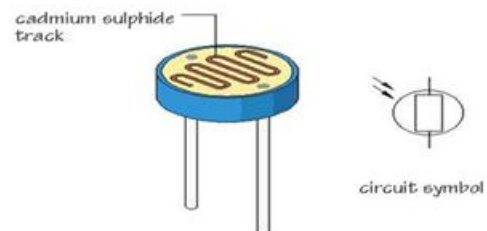
VI. MICRO CONTROLLER (PIC16F877A)

Peripheral Interface Controller (PIC) is a microcontroller developed by Microchip, PIC microcontroller is a fast and easy to implement program when compare other microcontrollers like 8051. With the ease of programming and ease of interfacing with other peripherals, PIC became a successful controller. The controller is an integrated chip that consists of Ram, Rom, CPU, Timers, Counters, etc. PIC is a controller that also consists of RAM, ROM, CPU, timers, counter, ADC (analog to digital converters), DAC (digital to analog converter). PIC also supports the protocols like CAN, SPI, UART for interfacing with other peripherals. PIC mainly used modified Harvard architecture and also supports RISC (Reduced Instruction Set Computer) by the above specification RISC and Harvard we can easily that PIC is faster than the 8051 based controller which is made up of Von-Neuman architecture.

LDR

LDR alone can't do this, need some other components to make this happen. So let's take a look at a simple circuit using

LDR and some other components to explain how it will turn on a light when it is dark



LDR or light-dependent resistor connected with some other components that will make the circuit work. As the name suggests the resistance of LDR is dependent on the amount of light that is falling on the LDR. Most of them will have a lower resistance with a higher amount of light and vice versa.

Here in this particular circuit, we are using the NPN transistor as a switch, to make stuff easier let me just say that the NPN transistor needs a positive voltage(I'm saying this just to make things simple but remember the BJT transistor which I have shown is a current controlled device) on its base to turn itself on

PIEZOELECTRIC MATERIALS

A piezoelectric transducer (also known as a piezoelectric sensor) is a device that uses the piezoelectric effect to convert energy into an electrical charge in order to measure changes in acceleration, pressure, strain, temperature, or force. A transducer is any device that converts one type of energy to another. One type of transducer is the piezoelectric material. The transducer converts energy into voltage when we squeeze this piezoelectric material or apply any force or pressure. This voltage is affected by the amount of force or pressure applied. Sensors are devices that identify or sense various types of physical quantities in the environment. Light, heat, movement, moisture, force, and vibrations could be inputs. Generally, the output is an electrical signal proportional to the voltage source.

An electric charge is generated across the faces of a piezoelectric material when a force is applied to it. This can be expressed as a voltage proportional to pressure (see diagram to the right). There is also an inverse piezoelectric effect, which occurs when a voltage is applied to a material and causes it to change shape. A given static force causes a corresponding charge to be applied across the sensor. However, due to poor insulation, internal sensor resistance, attached electronics, and other factors, this will deteriorate over time. As a result, piezoelectric sensors are typically ineffective for measuring static pressure. Even in the presence of constant pressure, the output signal will gradually decrease to zero. They seem to be, nevertheless, attentive to vibrant pressure changes across. This project, while modest in scale, is expected to make several significant contributions to the fields of renewable energy harvesting, smart infrastructure, and embedded systems education.

6.1 DEMONSTRATION OF LOW COST PIEZOELECTRIC HARVESTING

Most commercially available piezoelectric footstep systems cost hundreds or thousands of dollars, putting them out of reach for schools, community groups, and entrepreneurs in developing countries. By using generic piezoelectric discs (often salvaged from buzzers or gas igniters) and an Arduino, this project shows that functional energy harvesting can be

achieved for under \$50 in materials. This democratization of technology is a crucial step toward widespread adoption

6.2 HYBRID SOLAR PIEZOELECTRIC ARCHITECTURE

Most footstep harvesting projects rely solely on piezoelectric generation, which is intermittent (no footsteps = no power). Most solar projects are useless at night. By combining both, this project provides a 24-hour energy solution. During the day, the solar panel charges the battery. During the night, footsteps (which are more likely in the evening and early morning) provide top-up charging. The hybrid approach ensures the battery never fully drains under typical usage patterns.

VII. POTENTIAL REAL-WORLD APPLICATION(BEYOND THE PROTOTYPE)

If scaled successfully, the technology demonstrated here could be applied to:

- **Sidewalks in Urban Centers:** Busy pedestrian areas like train stations, shopping malls, and sports stadiums could generate significant power from foot traffic.
- **Remote Pathways:** Walking trails, bridge crossings, or staircases in rural or forested areas that lack grid power could be illuminated using footstep energy.
- **Dance Floors and Nightclubs:** A novel application—piezoelectric dance floors that power the venue's lighting, creating an interactive experience.
- **Military or Disaster Relief:** Portable piezoelectric mats could be deployed in temporary camps or disaster zones to harvest energy from personnel movement.
- **Smart Highways:** Embedding piezoelectric generators in road surfaces to power traffic sensors, warning lights, or even charge electric vehicles wirelessly (a longer- term vision).

VIII. CONCLUSION

The circuit works properly to turn the street lamp ON/OFF. After designing the circuit which controls the light of the street as illustrated in the previous sections. LDR sensor and the photoelectric sensors are the two main conditions in working the circuit. If the two conditions have been satisfied the circuit will do the desired work according to a specific program. Each sensor controls the turning ON or OFF of the lighting column. The street lights have been successfully

controlled by the controller. With commands from the controller, the lights will be ON in the places of the movement when it's dark. Furthermore, the drawback of the street light system using a timer controller has been overcome, where the system depends on a photoelectric sensor. Finally, this control circuit can be used on long roadways between the cities.

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