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**ABSTRACT**

Energy is that the essential demand of today's life. Thanks to the diminution of the energy sources, we'd like to develop the device which might harvest the wasted energy existing in our close atmosphere. Tribo\_electric\_nanogenerator (TENG) was developed as an associate in Nursing innovative paradigm for energy gather, which might harvest varied types of energy that exist in our day to day life together with vibrations, walking, ocean waves, human motions, raindrops, flowing water, a moving automobile, wind, rotation energy and mechanical triggering. Tribo\_electric nanogenerator (TENG) could be a novel energy further device to convert energy into electricity supported tribo\_electric principle. This paper reports tribo\_electric\_nanogenerator for with efficiency gather voltage from the motility motion of the robot's wheel, additionally paper works on designing robot's circuit doesn't would like any external reference battery exploitation electricity startup circuit. However, because the accessibility of harvest energy supply is intermittent, there's a requirement to plot a backup grid therefore to be able to store the electricity created by nanogenerator and thereby have a promptly obtainable supply of energy in the slightest degree times. This paper analyzes and presents an aphoristic review of renewable & gather energy technology, particularly in robotics, and learn additional on the way to incorporate the proper mobile automaton power supply, and seeks to demonstrate that renewable energy storage resolution will be hooked up and keep.

**KEYWORDS:** mobile robot, harvest energy.

**1. INTRODUCTION**

The robotic technology acting a significant role in recent life, the dearth of compact, efficient, and light-weight power sources impedes the conclusion of mobile robotic devices that operate autonomously for periods of hours, whereas the technology for mobile robotic platforms, communication, scientific discipline, and automation has accelerated, similar breakthroughs for power sources haven't unbroken pace. With the calculable population of mobile robots and therefore the ensuing demand for enormous energy consumption, build the ability supply powering a mobile mechanism may be an important call, poignant the mobile robotic method and output. Generally, batteries are the supply of energy for many mobile, embedded and remote system applications. However, within the fashionable, Renewable and harvest energy will give the answer as a viable energy supply to fulfill the special energy demands that are generally needed to control embedded systems and robots. Different interchange sources of vitality have been investigated for getting an economical frame of vitality to control different independent remote & versatile gadgets. Renewable & gathering vitality innovation arrangements will be required and engineers have as of now come up with different elective sources of vitality control frameworks into robots. The paper is organized as takes after: Section 2 gives a brief diagram of the vital sources for a robot. Section 3 gives a brief discourse of vitality collecting frameworks Section 4 presents the proposed framework and proposals for future inquiries about endeavors essential for the advancement of vitality generators. Section 5 concludes the paper.

**Power Solutions For Mobile Robot**

The selection of a mobile robotic power supply ought to be the choice created within the early stages of the planning since it impacts the whole system as a result of mobile robots are a unit expected to figure tireless hours, yielding excellent, precise results round the clock. Power grid alternatives embody batteries, fuel cells and generators, thermo-electric generators, super capacitors, flywheels and even non-storage choices. A helpful power technology ought to be self-contained and not depend upon external parts or energy. For this reason et al., alternative energy doesn't seem to be an associate degree possibility because of the long recharge time for



battery systems, counting on environmental conditions and therefore the comparatively giant cross-sectional space needed for a considerable power generation.

### Batteries

There are several variations on a subject matter, however the first battery technologies for industrial category mobile robots are Lead-Acid, Nickel-Cadmium, Nickel-Metal binary compound, and Lithium- particle. The sort of battery that's used for a mobile automaton varies reckoning on the protection, life cycle, and weight. Lead acid batteries are common, as are silver-cadmium batteries. Reversible batteries and first batteries are each used, batteries that don't seem to be reversible are usually a lot of power.

### Fuel Cells

A cell derives the energy it delivers from no matter "fuel" is provided, that is usually hydrogen. The electrical output is generated at a continuing level till the fuel runs out. There are many varieties of fuel cells, characterized by the sort of solution they use, and everyone is comparatively new decisions for mechanism development. 3 styles of fuel cells are chemical compound solution Membrane, Direct alcohol, and Solid compound solution.

### Solar Power Systems

The sun generates an enormous quantity of energy that is dissipated in the house, solely atiny low fraction of this energy reaching earth within the type of light-weight and alternative radiations. Solar power is, in theory, pretty straightforward to use, it's captured directly from the sun and hold on. As an example, IMRP was designed to run on fuel cells employing anonaggressive metal binary compound atomic number 1 storage system that stores additional energy on board than a chargeable battery may, and an acceptable methodology of storing solar power used H as a medium for storage, exploitation metal binary compound in [1].

### Renewable energy

Renewable energy will offer a viable energy supply to fulfill the special energy demands that square measure usually needed to work mobile robots. Renewable cells square measure renowned for his or her use as power sources for satellite, conservationist inexperienced energy campaigns, and pocket calculators. unremarkably these accommodates a renewable cell that charges a capacitance and alittle circuit that permits the capacitance to be charged up to a group voltage level then be discharged through the motor(s) creating it move, for example [2], that made-up a system for resupplying power to self-contained mobile instrumentality, together with associated fast{a set} station having associate external power supply and consisting of a high-frequency generator and a coil likewise as, on or within the instrumentality, a pick-up coil, a current filtering and rectifying device, a chargeable battery pack, and a microcomputer-controlled pursuit system. The personal computer is connected to the drive system of the instrumentality and applies a drive formula to the fastened station once the battery charge level drops below a preset level; the formula relies on a measuring of higher-frequency generator signal reception strength gradient.

### Ambient energy harvesting technology

Energy gathering could be a future energy offer for filling the gap between the energy offer and demand of reliable, clean and inexpensive energy, that originated from the windmill and water wheel, is wide being thought-about as an occasional maintenance answer for a good type of applications. The energy gathering sources may be accustomed increase the life and capability of the devices by either substitution or augmenting the battery usage. The devices, steam-powered by energy harvesters may be accustomed offer very important info on operational and structural circumstances by inserting them in inaccessible locations.

## 2. THE SOURCES OF HARVEST ENERGY

The process of extracting energy from the encompassing setting is termed as harvest home energy. Variety of sources of harvestable close energy exist, together with thermal energy, sound energy, frequency, light, energy & wind energy. Energy scavenging devices are a unit designed to capture the close energy encompassing the physics & convert it into usable power. An alternate supply of energy is needed within the fields of embedded systems, wireless detector networks and low power physics like MEMS devices. Additionally, with the restricted capability of finite power sources and also the want for provision energy for a life of a system, there's



a demand for self-powered devices [3]. There are a unit several sources of energy on the market for harvest home like:

#### **Thermal energy**

Thermal energy may be obtained from the warmth gift within the ambiance or from heat generated throughout some method. Either thermo-electric or pyro electrical effects may be wont to harvest energy [4].

#### **Mechanical energy**

Vibrations in some situations can be very large, like in case of the vibrations of civil structures like tall buildings, railroads, ocean waves, & even human motions & can give a better output power.

#### **Sound energy**

The sound energy is almost present continuously & at a considerable level in the environment for e.g. On the railway track, runway, shipyard, or on the road (engine noise of vehicles & horns), loud music played in clubs or parties, at construction sites & other such sources etc. [5].

#### **Wind energy**

This wind flow, or motion energy, when harvested using huge wind turbines, can be used to generate electricity on a large scale [6].

#### **Radio frequency**

Radiofrequency (RF) is any of the electromagnetic wave frequencies that lie in the range extending from around 3 kHz to 300 GHz [7].

#### **Light**

Light is radiation among a precise portion of the spectrum. Actinic ray is typically outlined as having wavelengths within the vary from 400–700 nanometers (NM), between the infrared (with longer wavelengths) & the ultraviolet (with shorter wavelengths). This wavelength means that a frequency variation of roughly 430–750 THz (THz). Solar cells square measure the foremost mature and commercially established energy-harvesting resolution [8] and after all, it exploited across a large variety of size scales and power levels. Whereas the price may be a key parameter for a large-scale electrical phenomenon generation, at the little scale of transportable electronic devices, this can be less of a problem, and lightweight convenience is instead the key limitation. Energy harvesting approaches that rework lightweight, heat and mechanical energy obtainable into current provide the potential of renewable power sources which may be want to directly replace or augment the battery. Such renewable sources may increase the period of time and capability of the system and mitigate the environmental impact caused by the disposal of batteries. [9] Designed a chemical element vibration-powered generator. A little magnetic attraction generator utilizing distinct elements and optimized for a coffee close vibration level primarily based upon real application knowledge was given in [10]. The generator delivered a half-hour of the facility provided from the atmosphere to helpful power within the load. the planning of miniature generators capable of changing close vibration energy into current to be used in powering intelligent device systems as delineated in [11]. a tool had been delineated which may manufacture a mean power of 157  $\mu$ \_W once mounted on the block of a automobile. Electricity Nanogenerators open new avenues for close power harvest through foldaway power choices and shrinking of power packages, thus [12] used vibration energy harvest by victimization electricity generators for wireless device devices. A system in [13] viewed motion driven miniature energy harvesters for appropriate applications, born-again close mechanical vibration into current for powering autonomous low power electronic systems. An entire energy harvest power provide for implantable pacemakers had been projected in [14]. The designed power provides enclosed an interior startup and didn't would like any external reference voltage, that lamb provided the input voltage for the circuit from the temperature distinction found between the body and also the ambiance. High output performance with variable rotation speeds and attractive force was achieved in [15], that a seesaw-structured tribo electrical nanogenerator (S-TENG) for expeditiously harvest current from the movement, motion of mechanical systems was projected to drive little physical science and also the wireless device node. [16] designed a self-powered electro\_spinning system, that was composed of a rotating disk TENG (R-TENG), a voltage-doubling rectifying circuit (VDRC), and a straightforward spinneret, that generated associate alternating voltage up to 1400 V, and

by employing a voltage-doubling rectifying circuit, a most constant direct voltage of eight.0 potential unit will be obtained below the optimum configuration and was able to power the electro\_spinning system for fabricating varied compound nanofibers.

### Storage Solutions

Ambient light-weight, thermal gradients, vibration/motion, or electromagnetic wave is often harvested to power electronic devices. At identical time, all energy-harvesting-based systems would like energy storage for times, once the energy can't be harvested (e.g., at midnight for solar-powered systems). Reversible batteries called "secondary" cells to differentiate them from "primary" or single-use cells square measure sometimes nominative for this task. Relying upon the energy harvester, the load demands, and numerous different system style concerns, they'r square measure several choices for a voltaic battery answer. High discharge rates, low self-discharge, high energy density, and different performance characteristics square measure immensely totally different among the electric cell chemistries presently on the market. Energy storage could be a key part of the energy gathering system as a result of it's a bridge of stability between the energy supply and also the load that gives a relentless energy be due Associate in Nursing otherwise variable environmental supply. The ability interface circuit condition the harvested energy to modify the charging of low capacitance batteries or supercapacitors and conjointly provides compatibility with the load necessities. "Storage has the impact of creating renewable energy even a lot of valuable as a result of you'll schedule it. You'll manage and dispatch it once you wish it," says Janice sculpturer, a United Nations agency leads the California Energy Storage Alliance and also the fresh supported international Energy Storage Alliance [17]. In general, energy is often held on in a very capacitance, super capacitance, or battery. The capacitors square measure used once the appliance has to give Brobdingnagian energy spikes. Batteries leak less energy and square measure thus used once the device has to give a gentle flow of energy. To assist perceive the varied approaches presently being deployed round the world, we've got divided them into six main categories: Solid State Batteries: a range of electrochemical storage solutions, including advanced chemistry batteries and capacitors

- A. **Flow Batteries:** batteries where the energy is stored directly in the electrolyte solution for longer cycle life, and quick response times
- B. **Flywheels:** mechanical devices that harness rotational energy to deliver instantaneous electricity
- C. **Compressed Air Energy Storage:** utilizing compressed air to create a potent energy reserve
- D. **Thermal:** capturing heat and cold to create energy on demand
- E. **Pumped Hydro-Power:** creating large-scale reservoirs of energy with water.

### 3. THE PROPOSED SCHEME "ANALYSIS & DESIGN "

#### Line Follower Arduino Robot

Line follower is an associate degree autonomous golem that follows either black line in white space or reference point within the black space. The golem should be ready to observe explicit line and keep following it. Line following may be a task within which golem needs to follow the road. It should be capable of taking varied degrees of turns to follow the bowed lines conjointly. The road sensors are a unit accustomed sense the road once the signal falls on the white surface, it gets mirrored, and if it falls on the black surface, it doesn't replicate this principle is employed to scan the Lines for the golem. The golem ought to be capable of taking varied degrees of turns and should be insensitive to environmental factors like lighting and noise. The golem are exploitation 2 IR detector combine which can have associate degree IR junction rectifier and Photodiode. Generally, IR rays are mirrored by the white surface, whereas a black surface can absorb IR rays. Within the line follower that builds, each the IR sensors are on the white surface. IR rays are emitted and mirrored back, which can be detected by the Photodiode, during this state the IR detector can send a HIGH digital signal ("1"). Similarly, once the detector is on a black surface IR rays are emitted and cannot be mirrored back, which can be absorbed by the black surface, during this state the IR detector can send an occasional digital signal ("0"). Thus, with these digital values one and zero, we are able to simply determine the state of the sensors. A line follower mechanism for the Arduino golem will be shown as below

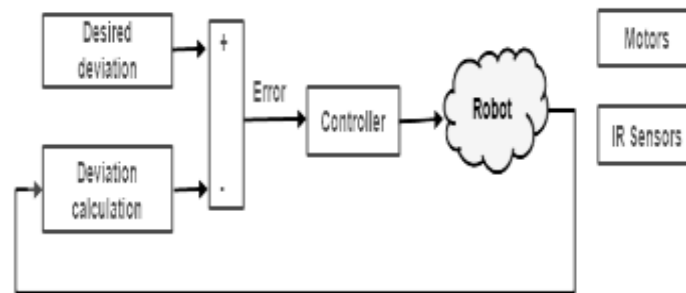


Fig. 1: - A line follower mechanism for the Arduino

### Required Hardware

Design Line Follower Arduino golem desires IC7805 transformer, L293D Motor Driver, IR light-emitting diode, try, 2 300-500rpm DC Motors, electricity (initial power supply), Chasis, Castor wheel, Wheels. The sensing element section contains IR diodes, potentiometer, Comparator (Op-Amp) and light-emitting diode. The potentiometer is employed for setting reference voltage at comparator's one terminal and IR sensors, square measure want to sense the road and supply an amendment in voltage at the comparator's second terminal. Then comparator compares each voltages and generates a digital signal at the output. Here this line follower circuit uses 2 comparators and 2 sensors. Luminous flux unit 358 is employed as a comparator. LM358 has inherent 2 low noise Op-amps. Arduino professional mini utilized in the management section for dominant whole the method of the line follower golem. The outputs of comparators square measure connected to digit identification number a pair of and three of the Arduino. Arduino reads these signals and send commands to the motive force circuit to drive line system follower, and driver section consists of the motor driver and 2 DC motors. The motor driver is employed for driving motors as a result of Arduino doesn't provide enough voltage and current to the motor. Therefore a motor driver circuit to induce enough voltage and current to the motor is supplemental. Arduino sends commands to the current motor driver then it drives motors. The golem uses 2 IR sensing element modules, particularly left sensing element, and right sensing element, and 2 500rpm DC motors. These motors work once they square measure connected to any DC power supply and therefore the direction of rotation of the motor is modified by ever-changing the polarity of the supply. IC L293D is employed to manage the motors that work with digital I/O. Assume that the input given to the motor through L293D is HIGH ("1") and LOW ("0") that build the motors to rotate in a very dextral direction, equally once the inputs square measure LOW ("0") Associate in Nursing HIGH ("1") the motor rotates in an anticlockwise direction. however once each the inputs square measure same (1 & one or zero & 0) the motors do not work. The digital signal given to the INPUT one, 2, three and four of L293D are thrown back to the OUTPUT one, 2, three and four severally. The INPUT a pair of and three of L293D is connected to ground, that is LOW ("0") and therefore the signal from the IR sensors square measure connected to INPUT one and four. Thence the worth of OUTPUT a pair of and there are perpetually LOW ("0") whereas the worth of OUTPUT one and four are HIGH ("1") once the IR sensing element is on the white surface and can be LOW ("0") once the sensing element is on black surface.

When both left and the right sensor senses white, then robot move forward.

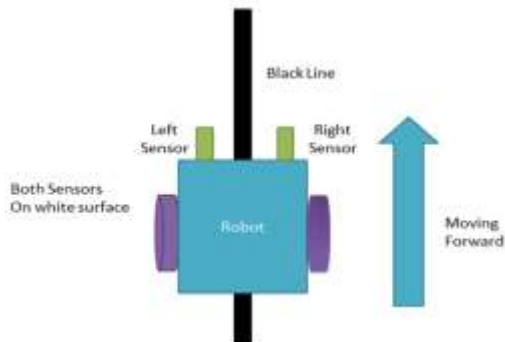


Figure (2 - a)

If the left sensor comes on the black line, then robot turn left the side.

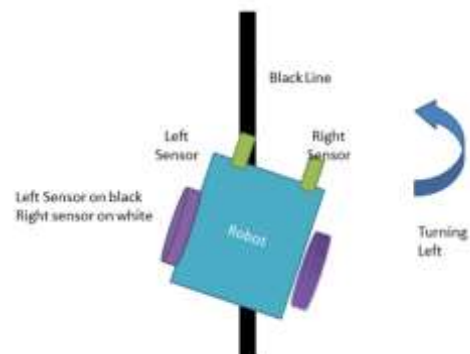


Figure (2 -b)

If the right sensor senses black line, then robot turn right side until both sensors come on the white surface. When white surface comes robot starts moving on forward again.

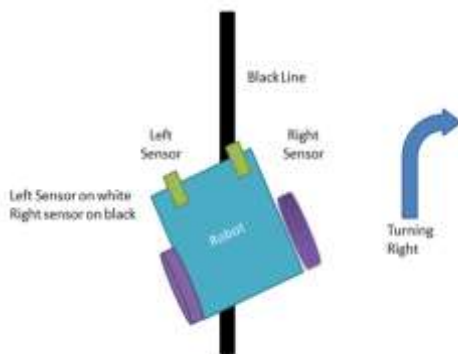


Figure (2 - c)

If both sensors come on the black line, the robot stops.

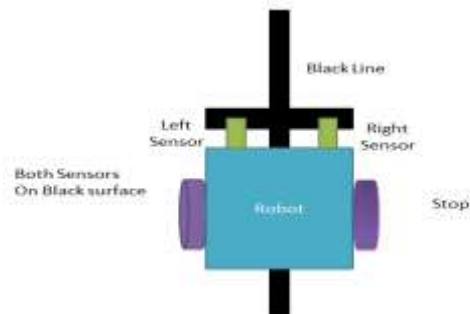


Fig (2 - d)

**Circuit diagram of robot**

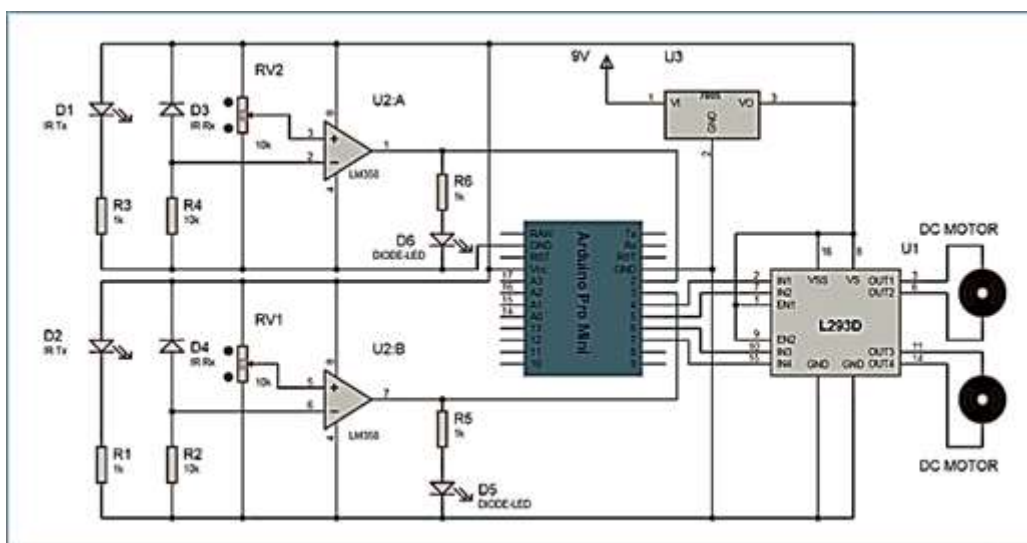


Fig. 3: - Circuit diagram of robot

Robots, like all devices to operate, want a supply of power so as to figure, that may be designed with a gasoline-powered engine and gas actuators. Except for the foremost electronic parts area unit supercharged by electricity, sometimes by batteries. This can be the foremost common and sensible thanks to power most robots, particularly mobile robots. In fact, most mobile robots on the market these days are a unit supercharged by renewable energy.

### Proposed Power Grid.

This Paper moves to vogue the facility system of a golem, that consists of two power systems. The first system is Self-Powered Startup victimization electricity, and conjointly the second system is that the energy harvester victimization integrated tribo\_electric\_nanogenerator. In this paper, the combo of electricity generation and energy gathering condition circuit unit accustomed verify the usefulness of self-power AI.

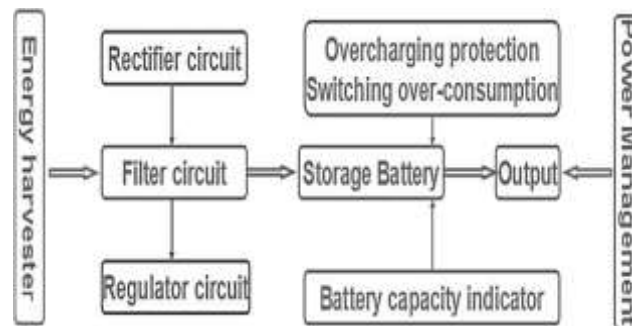


Fig. 4: - Piezoelectric Energy harvest system

### Self-Powered Startup using Piezoelectric

The battery is typically the raw power supply for a mechanism, however the complete electrical powering system consists of additionally a control circuit to stabilize and method the supply, and a switch to show on or off the facility. The self-powered system is remarkably engaging in building a property and environmental concern application to replay batteries. The piezo effect is that the conversion of applied mechanical force of internal electricity. The inverse (aka reverse or transverse) piezo effect converts applied electricity into the interior mechanical strain.

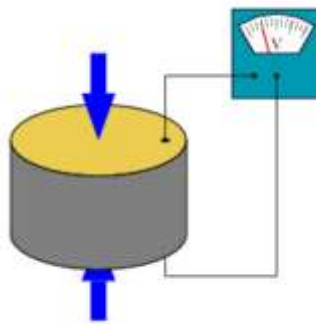


Fig. 5: -A piezoelectric disk generates a voltage when deformed

#### a) Component Details:

- 1) Rectifier (MIC DB 107)
- 2) DIA-Electric Capacitor (1, 10, 22, 47, 100, 150uf).
- 3) SPDT Switch
- 4) Piezo -Plate.
- 5) Jumper wire.



**b) Piezoelectric Circuit Diagram:**

The below is the schematic diagram of the **Piezoelectric Circuit**, where the energy stored in the capacitor will be dissipated only when the tactile switch is closed.

The energy stored in a capacitor is given by the equation:

$$E = \frac{1}{2}V^2C \quad (1)$$

For our circuit,  $C = 220 \mu F$ . When the multimeter shows 10 volts across the capacitor, the amount of energy stored is

$$E = \frac{1}{2}(10 V)^2(220 \mu F) = \mathbf{0.011 \text{ joules}} \quad (2)$$

If a single tap on the piezoelectric element increases the voltage from 2 V to 2.05 V, the amount of energy generated for each tap is

$$E = \frac{1}{2}(2.05^2 - 2^2)(220 \mu F) = \mathbf{0.000022 \text{ joules/tap}} \quad (3)$$

By using multimeter begins with addressing the power output as a function of vibration frequency.

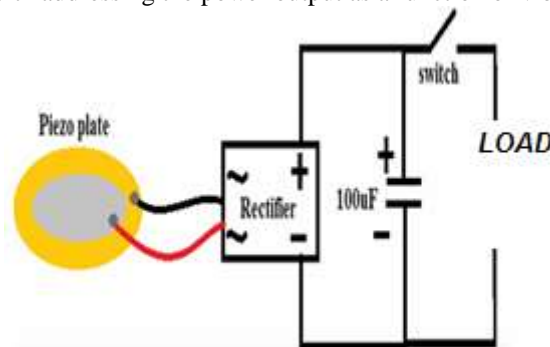


Fig.6: - Piezoelectric element generation circuit.

**2) Tir integrated triboelectricnanogenerator energy harvesting system for powering robot**

This paper provides a theoretical simulation technique for integrated tribo\_electric\_nanogenerator systems through integration the equivalent circuit model of tribo\_electric\_nanogenerators into the simulaion package. Paper represents integrated tribo\_electric\_nanogenerator energy gather systems that contain tribo\_electric\_nanogenerators, power management circuits, energy storage parts. A Wheel includes a rim and a tire. The rim, includes a hoop body shaping a central axis, 2 finagles, and 6-TENG into 2 rings. Once the vehicle moves and also the wheel roll, pressure generated by the bottom are going to be applied to the 6-TENG rings. Then, the TENG rings remodel the energy to electrical energy. Energy reproccess may be achieved and extra energy consumption may be avoided, wherever the TENG rings to transmit the electrical power to the electronic devices and/or the accumulator within the vehicle via wires. Thus, the extra electrical energy is employed for charging the battery and/or powering the electronic devices. The TENG rings to transmit the electrical power to the storage part to be kept.

**A Wheel comprising**

A ring body shaping a central axis thence, 2 flanges extending from the circumference of the ring body round the central axis, initial|a primary} annulled groove outlined within the circumference of every projection round the central axis; 2 TENG rings mounted within the several first annulled grooves and organized for manufacturing electrical power beneath pressure; and a tire insertion the rim.

**S-TENG design and characterization:**

A TENG film with a size of (1\*1) cm<sup>2</sup> was connected to the surface of a rubber wheel (7cmindiameter) with the rough surface facing outward. The rear conductor is connected to the metal rim on the wheel for causing charge assortment. The wheel is driven by a computer-controlled linear mechanism with controlled linear speeds.

**S-TENG on vehicle demonstration**

TENGs are connected to the tire surface of a golem (each back wheel has 3-TENGs). A bit of Al foil is placed on very cheap on the tire surface because the reference conductor. The TENG are often embedded into the

SPICE computer code as a basic component consisting of a voltage supply in serial reference to a capacitance. The system simulates in SPICE. The circuit accustomed store energy generated from TENG accumulated charge and keep energy during a capacitance. In actual applications, first, the load circuits are typically a mixture of resistors, diodes (rectifiers), transistors, capacitors, inductors (transformers), then forth. Besides, the important mechanical motion might be quite irregular. An influence management circuit is incredibly necessary to convert these AC outputs from TENGs to DC output



Fig. 7: - Structure of the TENG utilized with power management circuits

4. ANALYTICAL MODEL TRIBOELECTRIC ENERGY HARVESTING

The model is often improved to calculate the present, voltage, charge, and power output under completely different experimental conditions. This is often in distinction to the few prototypes that exist and is restricted to legendary straightforward geometries, derived mistreatment the parallel-plate condenser model [18].

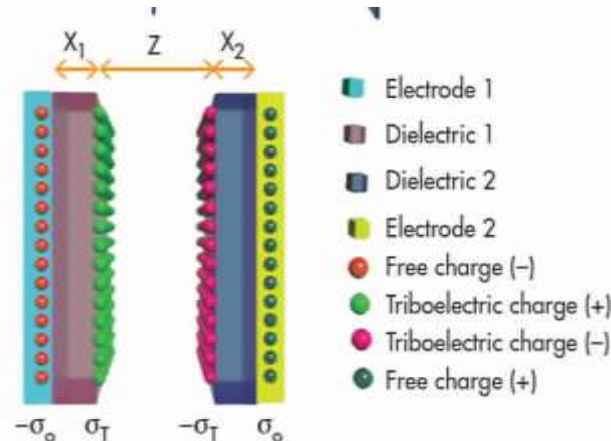


Fig.8: - The structure and the charge distribution of a typical contact-mode TENG

The figure shows the building and also the charge distribution of a typical contact-mode TENG. The model introduces the construct of a distance-dependent field of force ensuing mistreatment the finite dimensions of the charged layers and are applied to nearly any surface or pure mathematics (Fig. 8.).

## 5. VOLTAGE REGULATOR CIRCUIT DIAGRAM

Robots receive power regulation usually through a voltage regulator; this is often because when the robot is working, it desires the ability to be a similar invariable. As batteries square measure used, the battery life decreases. It starts out with full voltage, nine volts for a 9-volt battery, and reduces and reduces with usage. Unless stable, this might lead to a golem that moves at completely different speeds, has completely different light-weight brightness, and detector readings, supported battery freshness. This cannot be, regulate the voltage of the circuit voltage is employed. One {more reason|another excuse} for power regulation is that some components of the golem would like more power than alternative components. As an example, the DC motor your golem uses to maneuver typically desires additional power than associate LED. The subsequent circuit is that the answer to the matter. This circuit will offer +5V output at concerning a hundred and fifty mA current, however, it is often enlarged to one A once sensible cooling is more to the 7805 regulator chip. The circuit has overload and thermal protection, and also the capacitors should have enough high voltage rating to securely handle the input voltage feed to the circuit parts:

- C1 = 100uF-25V electrolytic capacitor, at least 25V voltage rating
- C2 = 10uF-25V electrolytic capacitor, at least 6-16V voltage rating
- C3 = 100nF-63V ceramic or polyester capacitor
- IC = 7805 regulator IC

### Circuit features

- Gives out well-regulated +5V output, output current capability of 100 MA
- Built-in overheating protection shuts down output when regulator IC gets too hot
- Very simple and easy to build
- Very stable +5V output voltage, reliable operation
- Easy to get components, uses only very common basic components

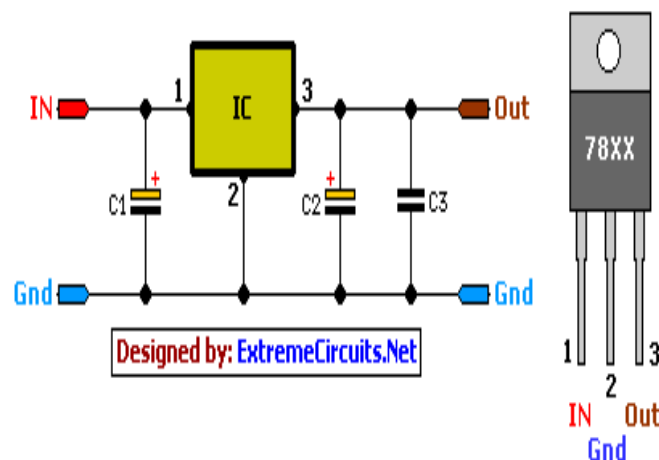


Fig.10: - Voltage Regulator Circuit Diagram

### Storage Solution "lithium-ion battery"

Lithium-ion rechargeable coin cell batteries were fabricated by using  $\text{LiCoO}_2$ /carbon black/binder mixture on Al foil (1 cm in diameter) as the anode, polyethylene (PE) as separator (2 cm in diameter), the graphite/carbon black/binder mixture on Al foil (1.5 cm in diameter) as the cathode. The electrolyte (1 M  $\text{LiPF}_6$  in 1:1:1 ethylene carbonate/dimethyl carbonate/diethyl carbonate) was injected inside between the anode and cathode before the coin cell was pressed firmly. The charging-discharging curves of these batteries were tested as shown in Fig.11, which exhibits a plateau voltage of  $\sim 3.8$  V [19].

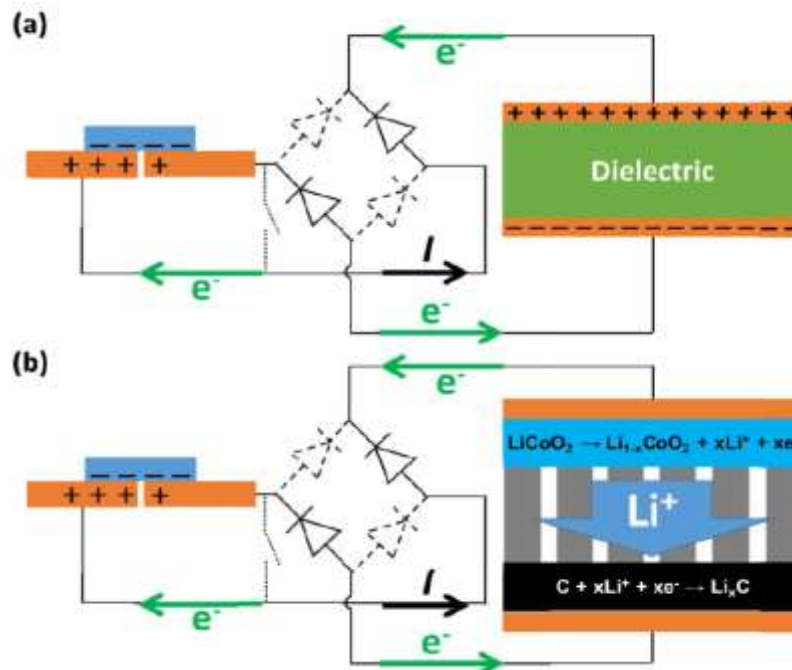


Fig. 11: - The charging process of a) a capacitor b) a fabricated the lithium-ion battery

## 6. CONCLUSIONS & FUTURE WORKS

Harvesting energies from environments to create up self-powered sensing system is a unit terribly helpful in our standard of living. Tribo\_electric\_nanogenerator (TENG) has been applied as a significant new technology to recover the sphere of vibration energy gathering and self-powered sensing, particularly for low-frequency vibrations like human motion, automobile, machine, and bridge vibrations. Tribo\_electric\_nanogenerators (TENGs) have attracted additional attention, as a set technology with characteristics of high responsiveness, high energy density, and low value. During this paper, each TENG-enabled vibration energy gathering from robot's tires, and electricity start-up circuit automaton incontestable. The open-circuit voltage and short-circuit charge of the TENG fastened within the rolling tire stay unchanged at the speed of the tire will increase, and works of coming up with robot's circuit don't want any external reference battery employing a electricity startup circuit.

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