Mobile phone charging by walking

by using a piezo sensor

Abstracts

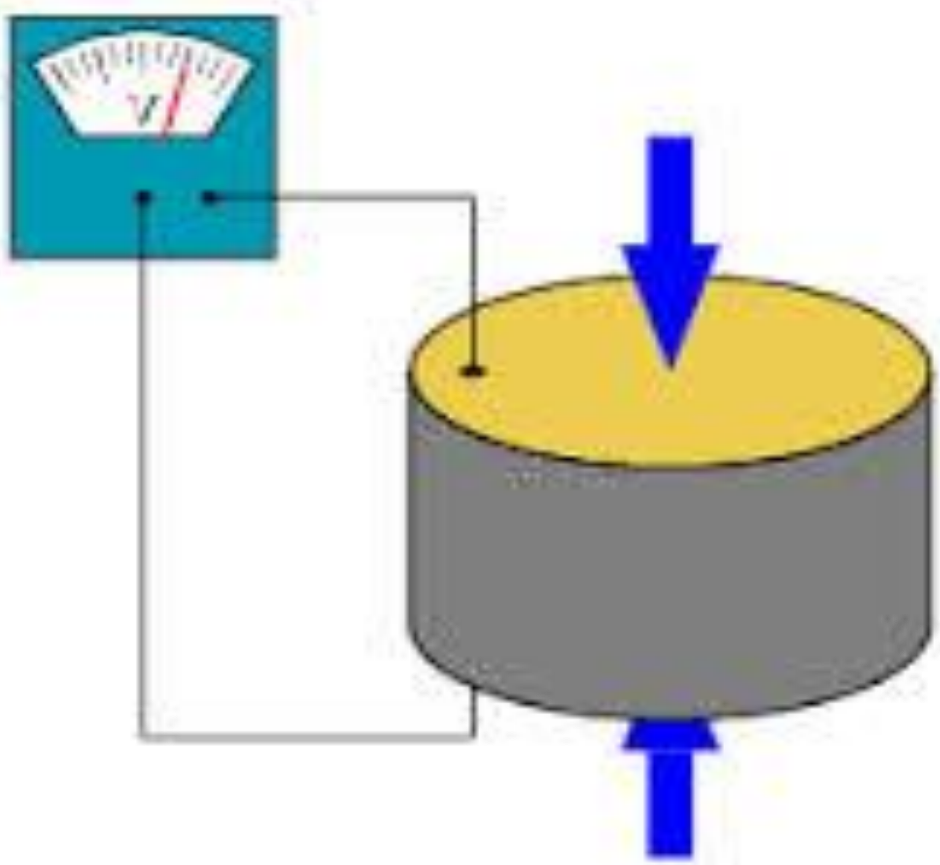
Human Beings has demanded the use of energy at an increased rate for the survival of the species ever since landing foot on the earth a few millions year ago for the first time. Due to this a lot of energy resources are being used ever since. The utilization of waste energy of foot power with human locomotion is very much useful and efficient for highly populated areas where the public transports, trains, public areas, offices etc. are all over crowded and millions of people are on the move all the time. If the utilization of the human bio-energy is made possible, it will be an invention of new level of efficiency and will be very useful energy source in crowded areas.

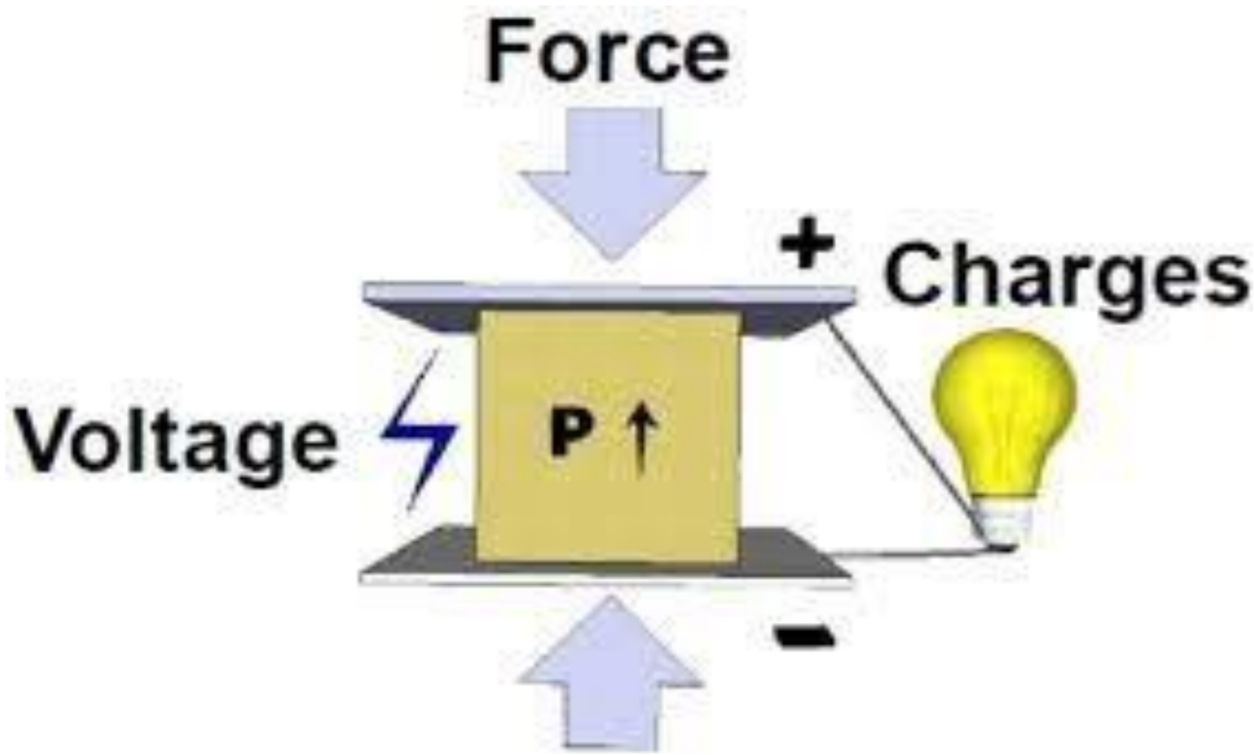
Design principles

We are trying to generating electricity power as a non-conventional method by walking or running. Non-conventional energy is very essential at this time to our nation. The energy generated using footstep is done by converting mechanical energy (from the footsteps) into the electrical energy by using a piezo electrical sensor. The energy produced is stored by a storage and can be used for charging a mobile phone by using a voltage regulator circuit. In this project of ours the conversion of the force into the electrical energy is done by the piezo electrical sensor which is included in the control mechanism carries.

Circuit descriptions

Piezo sensor- A piezoelectric sensor is a device that uses the piezoelectric effect to measure pressure, acceleration, strain or force by converting them to an electrical charge.





Piezoelectric sensors have proven to be useful tool and can be used in various fields for the measurement of various mechanical based quantities. They can also be used for quality assurance, process control and for research and development in many different industries all around the glove. The piezoelectric effect was discovered by Pierre Curie in 1880. But it was not until the 1950s that the piezoelectric effect is considered globally useful for industrial sensing applications. Since then, this measuring principle has been increasingly used since it is highly efficient and can be regarded as a dependable technology with an over par inherent reliability. It is used in various applications, such as in medical fields, aerospace fields, nuclear instrumentation, and can be also used as a pressure sensor in the touch pads of mobile phones. In the automotive industry, piezoelectric elements are also used to measure combustion when developing an internal combustion engine for any industrial purpose. These sensors are either directly used in an additional hole of the cylinder head or the (spark/glow) plug is equipped with a built in miniature piezoelectric sensor.

The rise of piezoelectric technology can be directly related to a number of inherent advantageous possibilities. The known high modulus of elasticity of piezoelectric materials can be compared to that of many materials and goes up to10^6 N/m^2[Piezoelectric sensors are electromechanical systems that react to compression, the sensing elements are with zero deflection. The reason why piezoelectric sensors are so rugged is this, and they have an unnatural high natural frequency and an exceptional linearity over a wide amplitude range. Moreover, piezoelectric technology is insensitive to electromagnetic fields and radiation (in open areas too), enabling measurements under harsh conditions comparatively easier. Some materials which are used (especially gallium phosphate or tourmaline) have high sustenance even at high temperature, enabling the sensors to even work under the outstanding temperature of up to 1000 °C. Tourmaline show spyro electricity along with the piezoelectric effect; this is the ability which makes it able to generate an electrical signal when the temperature of the crystal changes. This effect is also associated0 with piezo-ceramic materials.

Battery

An electric **battery** is a kind of storage device that consists of multiple electrochemical cells that converts stored chemical energy to electrical energy. Every battery consists of a negative electrode (anode) that has charged ions, a positive electrode (cathode) that has discharged ions, an electrolyte that allows ions to move from the anode to the cathode of the battery during discharge (and return during recharge) and 2 terminals that allow the current to flow to the load of the battery to work.

Batteries are are of two types:

1.> primary (single-use or "disposable") that are usable once and disposed of.

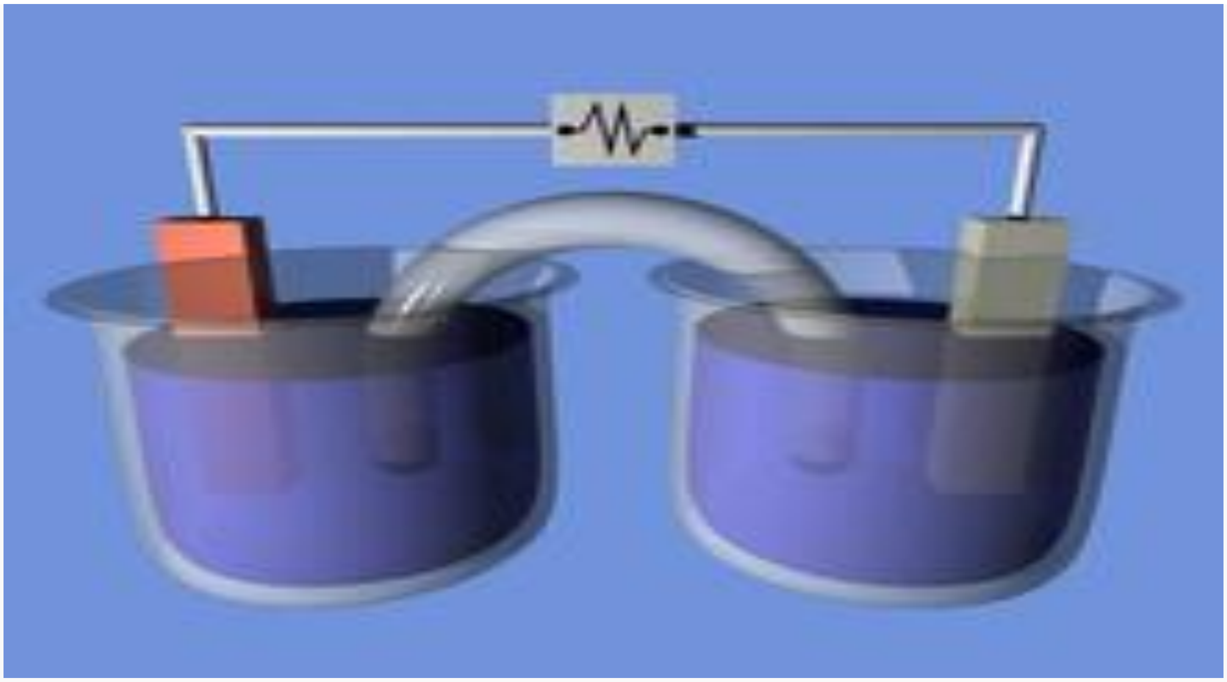
2.> Secondary (rechargeable batteries) that can be recharged multiple times when it is discharged.

Batteries are made from several materials including various metals along with carbon and polymers. The most common are lead-acid batteries that are used in vehicles and another is lithium ion batteries that are used for portable electronics. Batteries are of many shapes and sizes, from miniature cells used to power the hearing aids and wristwatches. And there are battery banks of the size of a room that provide backup power for telephone exchanges and offices where there are computers.

Batteries have received a good research and development, because they are expected to provide a solution for storage of energy in a transition from usage of fossil fuels to an alternative energy, both for the use in transportation and electricity production and to power portable devices of any kind.

Principle of operation

Main article: Electrochemical cell



Above is a diagram of a voltaic cell for demonstration purposes. In this the two half-cells are linked by a salt bridge separator that allows only the transfer of ions. Water molecules are not allowed to pass.

As we know, batteries convert chemical energy directly to electrical energy. It has some number of voltaic cells in it. Each cell consists of two half-cells connected in a series by a conductive electrolyte of anions and cations. One half-cell consists electrolyte and the anode (negative electrode), the electrode towards which anions migrate; Another half-cell includes electrolyte and the cathode (positive electrode) electrode to which cations (positively charged ions) migrate. The battery is powered by Redox reactions. Cations are less in number (electrons are added) at the cathode during the charging process, and anions are oxidized (electrons are removed) at the anode during the discharge process. The electrodes should not touch each other, but are electrically connected with the help of electrolyte. Some cells have different kind of electrolytes for each half-cell. A separator allows only the ions to flow between half-cells, but prevents mixing of the electrolytes.

The half-cells have an electromotive force (or EMF), which is determined by its ability to drive electric current from the interior to the exterior of the given cell. The resultant EMF of the cell is the difference between the EMFS of its half-cells. Thus, if the electrodes have EMF ($\mathcal{E}_1$ and $\mathcal{E}_2$), then the net EMF is ($\mathcal{E}_2 - \mathcal{E}_1$); So we can say that the net EMF is the difference between the reduction potentials of the half-reactions. The electrical driving force or ΔV_{bat} across the terminals of a given cell is known as the terminal voltage (difference) and is measured in (V) volts. The terminal voltage of a cell that is neither charging nor discharging is called the open-circuit voltage and is equal to the EMF of the cell. Because of the internal resistance, the terminal voltage of a cell that is being discharged is smaller in magnitude in comparison to the open-circuit voltage and the terminal voltage of a cell which means charging exceeds the open-circuit voltage. An ideal cell has near to zero internal resistance, so it can maintain a constant terminal voltage of $\mathcal{E}$ until it is exhausted, then dropping it to zero. If such a given cell maintained 1.5 volts and stored a charge of one coulomb then on facing complete discharge it would perform 1.5 joules of work. In actual cells, the internal resistance of the cell increases while being discharged and the open circuit voltage also decreases while under discharge. If the resultant voltage and resistance are plotted against time, the resulting graphs are a typical curve; the shape of the curve varies according to the chemistry and internal arrangement which is employed.

The voltage that is developed across a cell's terminals depends on the amount of energy released from the chemical reactions of its electrodes and electrolyte. As we know, Alkaline and zinc–carbon cells have different chemistries, but approximately the same EMF of 1.5 volts; Similarly, NiCd and NiMH cells have different chemistries, but approximately the same EMF of 1.2 volts. The high amount of electrochemical potential changes in the reactions of lithium compounds give lithium cells EMFs of 3 volts or more.

INVERTING AMPLIFIER:

In inverting amplifiers only one input is applied to the inverting input terminal. The non-inverting input terminal is grounded, since $\upsilon 1 = 0$ V , and $\upsilon 2 = \upsilon_{in}$, therefore $\upsilon 0 = -A\upsilon_{in}$

The negative sign before v0 indicates that the output voltage is out of phase with respect to input by 180 degree that means it is of positive polarity. Thus, in the inverting amplifier the input signal is amplified by gain A and is also inverted at the output terminal.

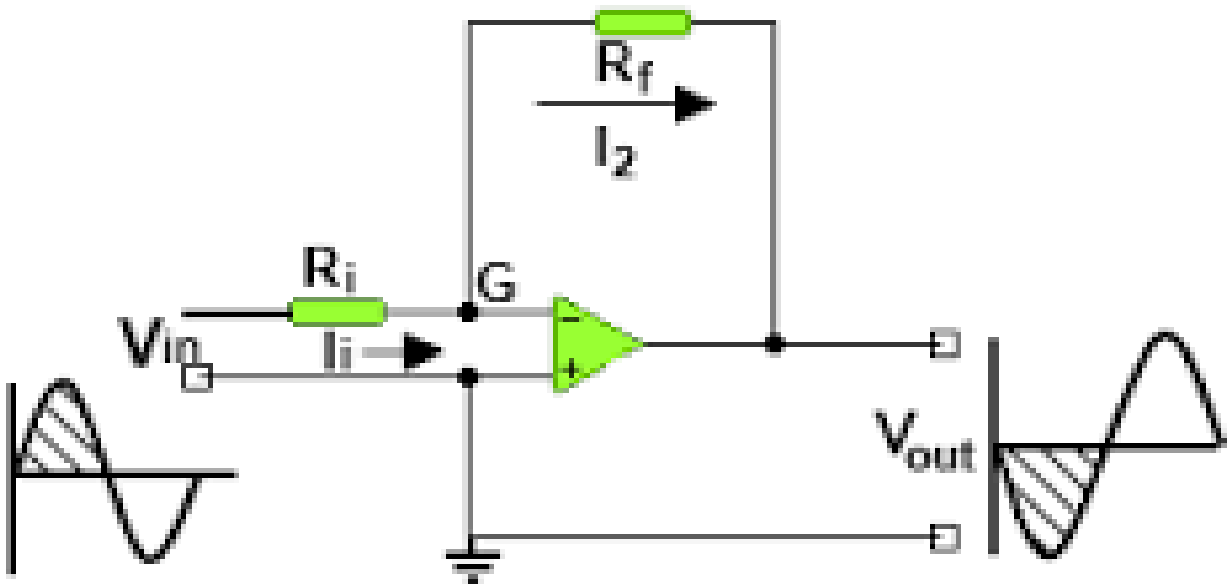


Figure (a) Inverting Amplifier

The Inverting Operational Amplifier

We know that the Open Loop Gain, (Avo) of an operational amplifier can be very high, around 1,000,000 (120dB) or more. However, this very high gain is of no practical use to us as it makes the amplifier both unstable and hard to control because small input signals, just a few micro-volts, (μV) would be just enough to cause the output voltage to saturate and swing towards one or the other of the voltage supply rails losing complete control of the output.

The open loop DC gain of an Operational Amplifiers is extremely high we can therefore lose some of the high gain by connecting a suitable resistor across the amplifier from the output terminal back to the inverting input terminal to reduce and control the overall gain of the amplifier. Then it produces an effect called Negative Feedback, and thus produces a very stable Operational Amplifier based system.

Negative Feedback is a process of "feeding back" a fraction of the output signal back to the input signal, but to make the feedback negative, we have to feed it back to the negative or "inverting input" terminal of the op-amp using an external Feedback Resistor called R*ƒ*. The feedback connection between the output and the inverting input terminal forces the differential input voltage towards zero.

This effect produces a closed loop circuit to the amplifier resulting in the gain of the amplifier to be called as its Closed-loop Gain. A closed-loop inverting amplifier uses negative feedback to precisely control the overall gain of the amplifier, at a cost of reduction in the amplifiers gain.

This negative feedback generally results in the inverting input terminal to have a different signal on it than the original input voltage because it will be the sum of the input voltage and the negative feedback voltage giving it the label "*Summing Point*". Therefore, separating the real input signal from the inverting input by using an Input Resistor, Rin is a solution.

As we are not going to use the positive non-inverting input, it is connected to a common ground also known as zero voltage terminal as shown below, but the effect of this closed loop feedback circuit always results in the voltage potential at the inverting input terminal being equal to that at the non-inverting input terminal producing a *Virtual Earth* summing point as it will be having a same potential as the grounded reference input. We can also say that the op-amp becomes a “differential amplifier”.

Inverting Operational Amplifier Configuration

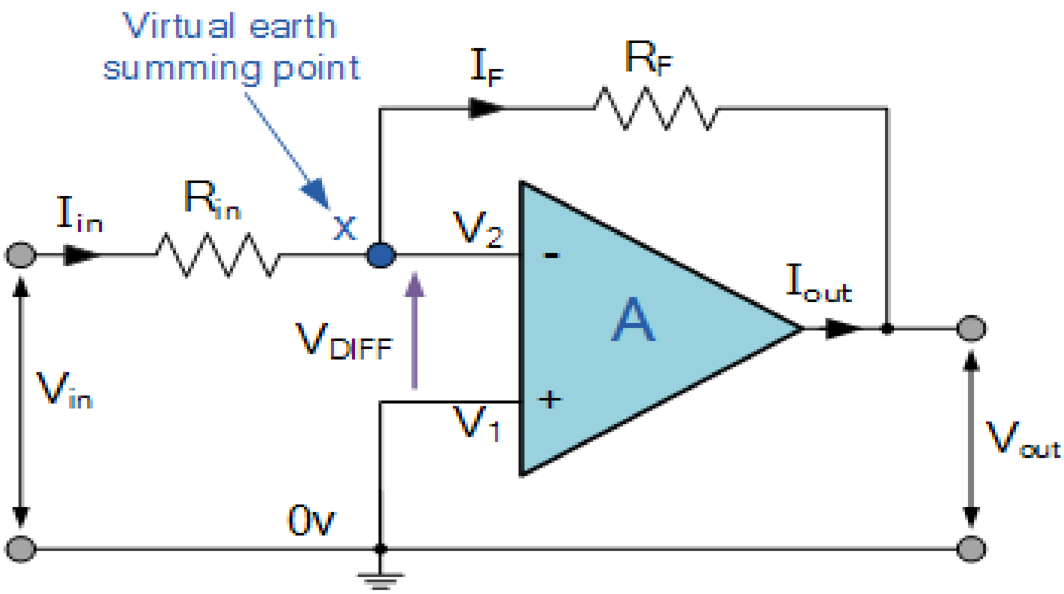
In the Inverting Amplifier circuit the operational amplifier is generally connected to the feedback to produce a closed loop operation. When we are dealing with operational amplifiers, there are two very important rules to remember about the inverting amplifiers, these are:

1.> “No current flows into the input terminal”

2.> “V1 always equals V2”.

However, in real world op-amp circuits both of these rules are not followed properly.

This happens because the junction of the input signal and feedback signal (X) is at the same potential as the positive (+) input which is at zero volts or ground then, the junction is called a “Virtual Earth”. Because of this virtual earth node the input resistance of the amplifier is typically equal to the value of the input resistor, Rin and the closed loop gain of the inverting amplifier are to be set by the ratio of the two external resistors.



We said above that there are two very important rules to remember about Inverting Amplifiers or any operational amplifier for that matter and these are.

1. No Current Flows into the Input Terminals

2. The Differential Input Voltage is Zero as V1 = V2 = 0 (Virtual Earth)

These two rules can be derived from the equation for calculating the closed-loop gain of an inverting amplifier, using first principles.

Current (i) flows through the resistor network as shown.

Then, the Closed-Loop Voltage Gain of an Inverting Amplifier is given as.

and this can be transposed to give Vout as:

$$i = \frac{Vin - Vout}{Rin + Rf}$$

$$\text{therefore, } i = \frac{Vin - V2}{Rin} = \frac{V2 - Vout}{Rf}$$

$$i = \frac{Vin}{Rin} - \frac{V2}{Rin} = \frac{V2}{Rf} - \frac{Vout}{Rf}$$

$$\text{so, } \frac{Vin}{Rin} = V2\left[\frac{1}{Rin} + \frac{1}{Rf}\right] - \frac{Vout}{Rf}$$

$$\text{and as, } i = \frac{Vin - 0}{Rin} = \frac{0 - Vout}{Rf} \qquad \frac{Rf}{Rin} = \frac{0 - Vout}{Vin - 0}$$

$$\text{the Closed Loop Gain (Av) is given as, } \frac{Vout}{Vin} = -\frac{Rf}{Rin}$$

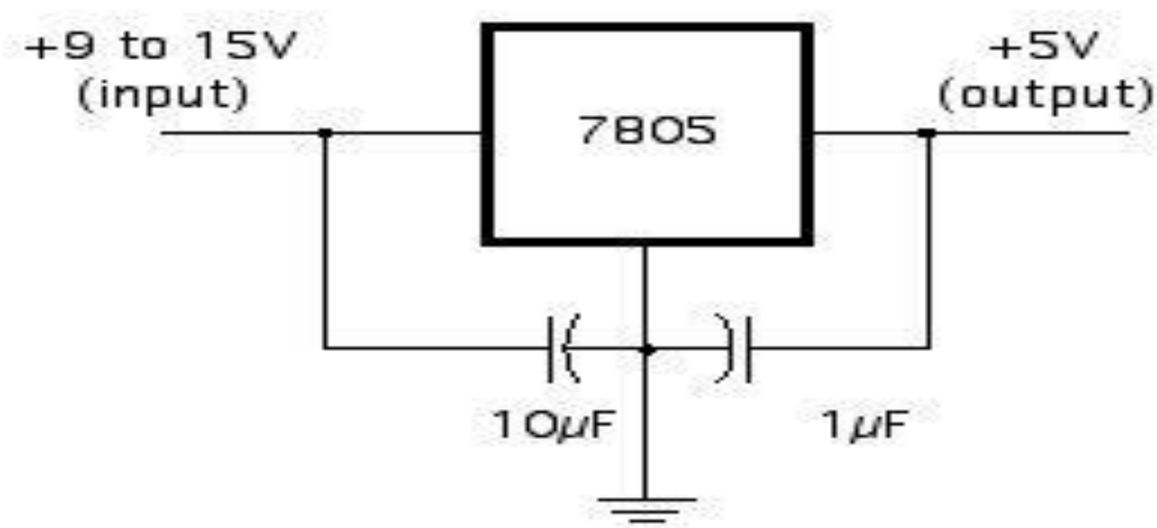
Linear Output

The obtained negative sign in the equation indicates the inversion of the output signal in comparison to the input signal as it is 180^{o} out of phase. This is because of the feedback being negative in value.

The equation for the output voltage Vout shows that the circuit is linear in nature for a fixed amplifier gain as we know Vout = Vin x Gain. This property is useful for converting a smaller sensor signal to a much larger voltage.

Voltage regulator

7805 is a **voltage regulator** integrated circuit. It is a member of 78xx series of a fixed linear voltage regulator ICs. Normally, voltage source in a circuit have fluctuations and would not give the fixed voltage output. At that stage the **7805 voltage regulator IC** maintains the output voltage at a constant magnitude. The xx in 78xx signifies that the fixed output voltage which it is designed to provide. 7805 IC provides +5V regulated power supply. Capacitors of suitable values can be connected at input pins and output pins depending upon the respective voltage levels.



Features

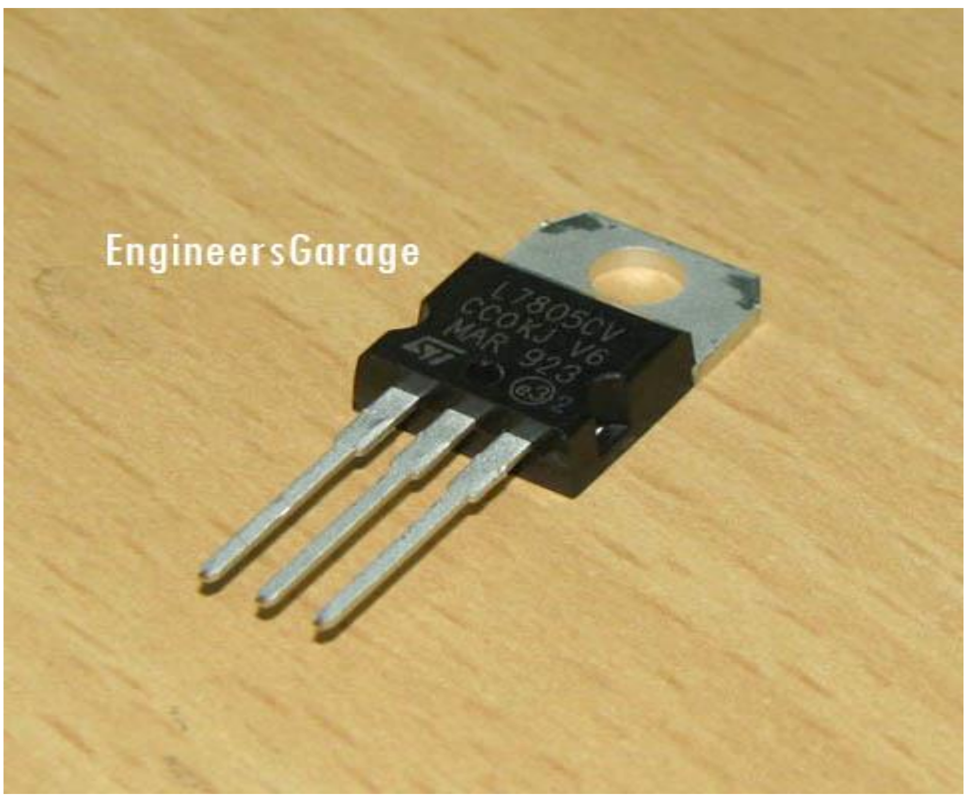
• Output Current up to 1A

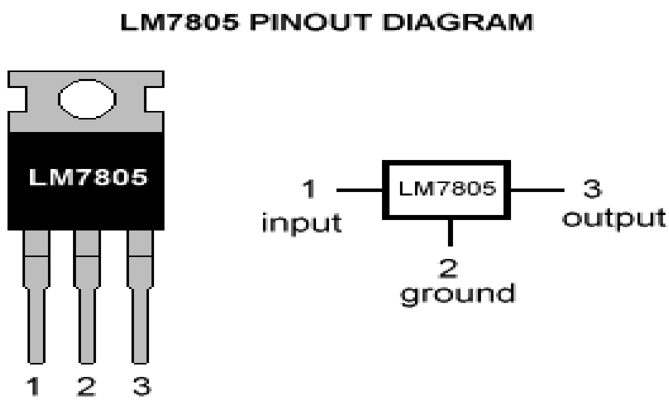
• Output Voltages of 5, 6, 8, 9, 10, 12, 15, 18, 24V

• Thermal Overload Protection

• Short Circuit Protection

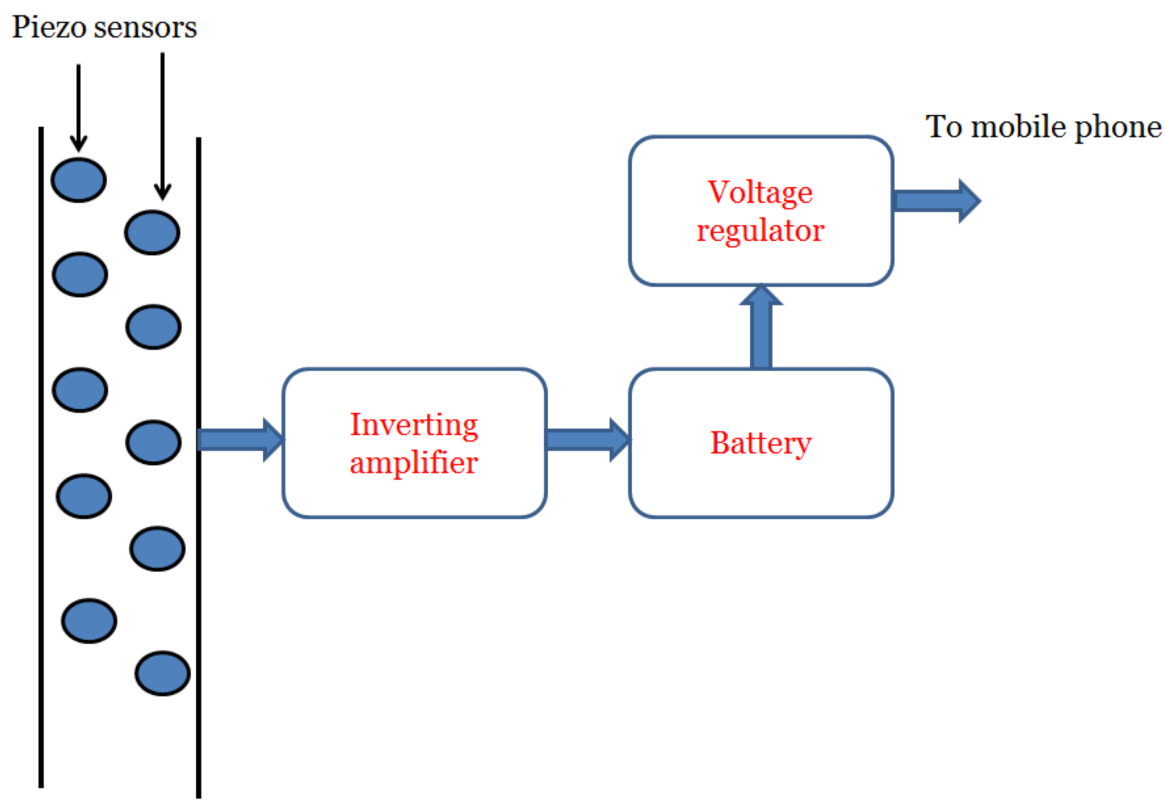
• Output Transistor Safe Operating Area Protection





PIN NO.	PIN NAME	DESCRIPTION OF THE PIN
1	I/P	In this pin of the IC positive unregulated voltage is given in the regulation.
2	GND	In this pin where the ground is given. This GND pin is neutral for equally the input and output signals.
3	O/P	The output of the regulated 5V volt is generally taken out from this pin of the IC regulator.

Pin No	Function	Name
1	Input voltage value (5V-18V)	I/P
2	Grounded (0V)	GND
3	Regulated output value; 5V (4.8V-5.2V)	Output



<u>Mobile phone charging by walking using piezo sensor</u>