Electronic Design Lab

PROJECT REPORT

SOLAR CUM VIBRATION HARVESTING MOBILE CHARGER

2017-18

GROUP: DD19

Niranjan Suthar 15D070034
Ritesh kumar 15D070033
Uday Chaudhary 15D070064

Under the guidance of

Faculty Mentor: **Prof. Joseph John**
EE Dept., IIT Bombay

TA/RA: Jishnu, Kaushal

Abstract

As we know there is an absolute need to harvest renewable energy sources, the most easily accessible among them is the solar energy. The most commonly used device in our generation are cell phones, tablets and likely gadgets. So why not charge the cells of these devices with the solar energy. In this project we are trying to make a solar cum vibration harvesting mobile charger

Two challenges were involved in this task. First to get almost constant 5V output from the solar panel and even if we manage to get constant 5V output we also want sufficient current (~0.2mA) from the panel to charge the phone. To get higher current we needed bigger solar panel or more panels in parallel and that will hamper the portability of the device. An intermediate way out was to charge a Li ion cell of lesser output voltage with the solar panel and then eventually use that cell to charge the phone.

To execute that, we convert the output of the cell to 5V DC using a Boost converter and used a charging circuit to charge the Li ion cell. Now coming to the vibration part, it is really difficult to get power from a vibration source unless the vibration is very high. We are deploying the simple magnet and coil for our project to get ac voltage which we are rectifying to get the DC voltage.

Contents

Chapter 1: Introduction

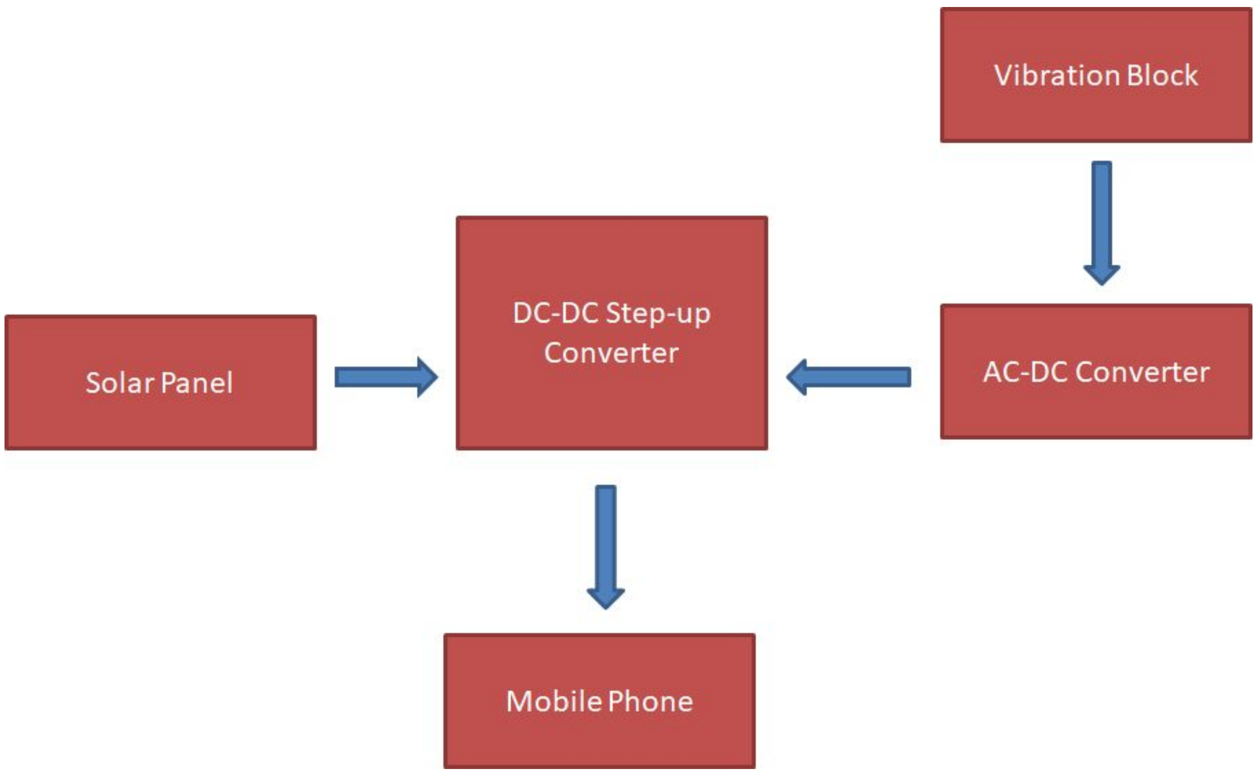
1.1 Objective of the Project

Our objective is to build a mobile charger system that can generate power from the energy sources which we generally ignore to harvest and deploy, the sunlight and the energy from the vibrations. We aim to make a charger for low voltage application charging(5V).
Our project product will be highly useful in long distance train journeys where we can get both the sources of energy simultaneously. This system will also be useful in the rural areas where there is a shortage of electricity.

1.2 Motivation for the work

In today's era, pollution is a very big problem all over the world, especially in developing countries like India. World is moving toward renewable fuels like solar energy, dams (potential energy due to hieght) f or electrical and other use by reducing the use of coal and petroleum fuels.In country like india the sunlight has good intensity 8-9 months out of year which is suitable for solar energy development.there are so many other unutilised non polluted energy sources which we should use as a progressive country.In the country like india population is increasing by 20% decadely , which is witnessing a skyrocketing of energy costs and an exponential decrease in the supplies of fossil fuels, there arises a need to develop methods for judicious use of energy which lay emphasis on protecting the environment as well.

1.3 Block Diagram



This shows the block diagram of our project.

1. Solar Panel: Generation of power by the sunlight
2. Vibration Block: Generation of power by changing the magnetic field in the induction coil
3. AC-DC Convertor: The voltage produced by Vibrational Part is AC, but we need regulated DC voltage to charge mobile phone.So this block shows the the conversion of AC to DC voltage.
4. DC-DC Step Up Converter: The Output voltage of Solar Panel Block and AC-DC Convertor is DC and less than 5V but not regulated at constant value of 5V. So we need a switching regulator i.e. DC-DC Step Up Converter to regulate the voltage at Constant value of 5V.
5. Mobile Phone: As we have regulated the voltage at constant value of 5V. So we can give this to our mobile phone as input for charging.

Chapter 2: Project Design

2.1 Steps to design

- We need to charge our phone using a solar cell first.
- Our Solar cell rating is 5V, 200mA.
- We get the maximum of 5V at full intensity sunlight, otherwise <5V.
- Our phone and most of the gadgets contains Li-ion batteries now-a-days.
- Li-ion cells have voltage range between 3.0V/cell (discharged) to 4.2V/cell(charged) and midway voltage as 3.7V.
- So our phone needs to be charged between the voltage range of 4.2V-5.2V.

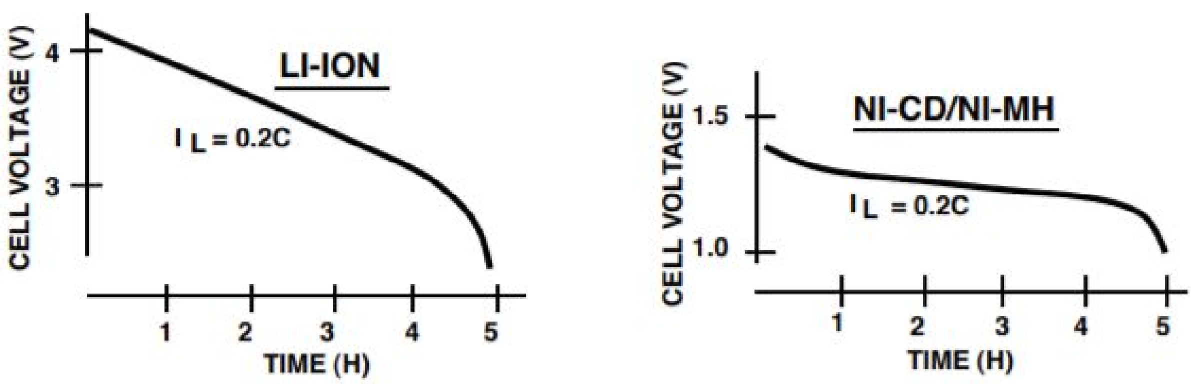


FIGURE 3. CELL DISCHARGE CURVE

- Since the discharge curve is quite flat for NI-CD cell, we can consider linear regulators for them, but Li-ion cells should be charged with a switching regulator to obtain good energy conversion efficiency in the power supply.
- Now we need to design a switching regulator circuit to maintain a constant voltage of 5V output during the charging of the phone.

2.2 Linear vs Switching Regulator

Voltage regulator is a circuit which maintains desired voltage at the output with varied input range as long as it can supply sufficient current.
There are two kind of regulators:

1. Linear Regulator
2. Switching regulator

Linear Regulator: A linear regulator operates by using a voltage-controlled current source to force a fixed voltage to appear at the regulator output terminal. Generally all the linear regulators have bipolar junction transistors working as a current source to supply sufficient current to meet the reference voltage. Since these transistors are working in linear (amplifying) region, there occurs inevitable power loss in them.
The control circuitry sense the output voltage, and adjust the current source (as required by the load) to hold the output voltage at the desired value. The design limit of the current source defines the maximum load current the regulator can source and still maintain regulation. The output voltage is controlled using a feedback loop, which requires some type of compensation to assure loop stability.

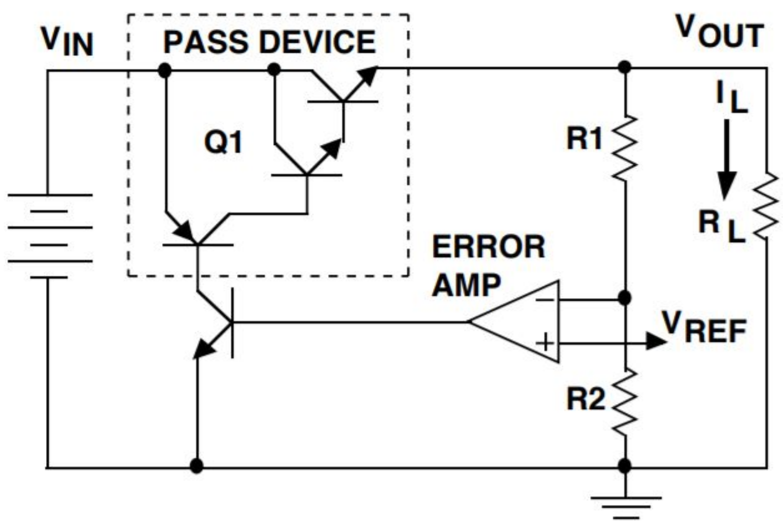


FIGURE 2. DIAGRAM OF A TYPICAL LINEAR REGULATOR

Disadvantages of Linear Regulators-

1. Range of application: It can be used only as a step down regulator.
2. Average Efficiency: Normally linear regulators have 30% to 60% efficiency. The power is lost in the form of heat. Heat sink is required over the transistor for the heat dissipation. It occupies space and increase in system cost.

Switching regulator:

Switching regulators are efficient voltage regulator devices
We are using a Boost converter as a switching regulator to regulate the output at constant 5V

2.3 Simple Step-Up Converter

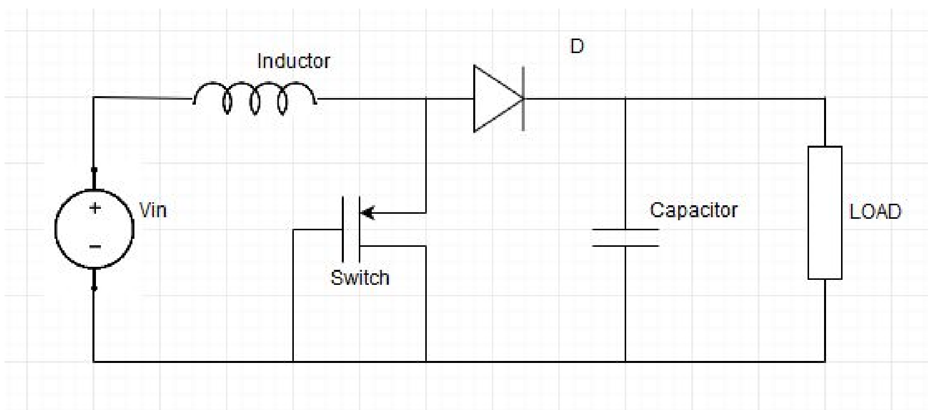


Figure 1

The key principle that drives the boost converter is the tendency of an inductor to resist changes in current by creating and destroying a magnetic field.

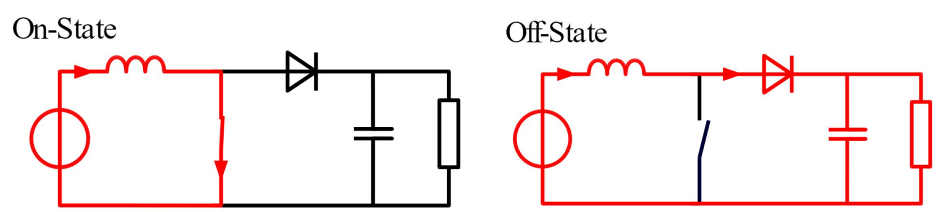


Figure-2

(a) When the switch is closed, current flows through the inductor in clockwise direction and the inductor stores some energy by generating a magnetic field.

(b) When the switch is opened, current will be reduced as the impedance is higher. The magnetic field previously created will be destroyed to maintain the current towards the load. As a result, two sources will be in series causing a higher voltage to charge the capacitor through the diode D.

The basic principle of a Boost converter consists of 2 distinct states (see figure 2):

- in the On-state, the switch S (see figure 1) is closed, resulting in an increase in the inductor current
- in the Off-state, the switch is open and the only path offered to inductor current is through the flyback diode D, the capacitor C and the load R. This results in transferring the energy accumulated during the On-state into the capacitor

Some Calculations:

During the On-state, the switch S is closed, which makes the input voltage (Vi) appear across the inductor, which causes a change in current (IL) flowing through the inductor during a time period (t) by the formula:

$$\frac{\Delta I_L}{\Delta t} = \frac{V_i}{L}$$

Where L is the inductor value. At the end of the On-state, the increase of I_L is therefore:

$$\Delta I_{L_{On}} = \frac{1}{L}\int_0^{DT} V_i \, dt = \frac{DT}{L} V_i$$

D is the duty cycle. It represents the fraction of the commutation period T during which the switch is On. Therefore, D ranges between 0 (S is never on) and 1 (S is always on). During the Off-state, the switch S is open, so the inductor current flows through the load. If we consider zero voltage drop in the diode, and a capacitor large enough for its voltage to remain constant, the evolution of I_L is:

$$V_i - V_o = L\frac{dI_L}{dt}$$

$$\Delta I_{L_{Off}} = \int_{DT}^{T} \frac{(V_i - V_o)\, dt}{L} = \frac{(V_i - V_o)(1 - D)\, T}{L}$$

So, the variation of I_L during the Off-period is as-

As we consider that the converter operates in steady-state conditions, the amount of energy stored in each of its components has to be the same at the beginning and at the end of a commutation cycle. In particular, the energy stored in the inductor is given by:

$$E = \frac{1}{2} L I_L^2$$

So, the inductor current has to be the same at the start and end of the commutation cycle. This means the overall change in the current (the sum of the changes) is zero:

$$\Delta I_{L_{On}} + \Delta I_{L_{Off}} = 0$$

$$\Delta I_{L_{On}} + \Delta I_{L_{Off}} = \frac{V_i D T}{L} + \frac{(V_i - V_o)(1 - D)T}{L} = 0$$

Therefore,

$$\frac{V_o}{V_i} = \frac{1}{1 - D}$$

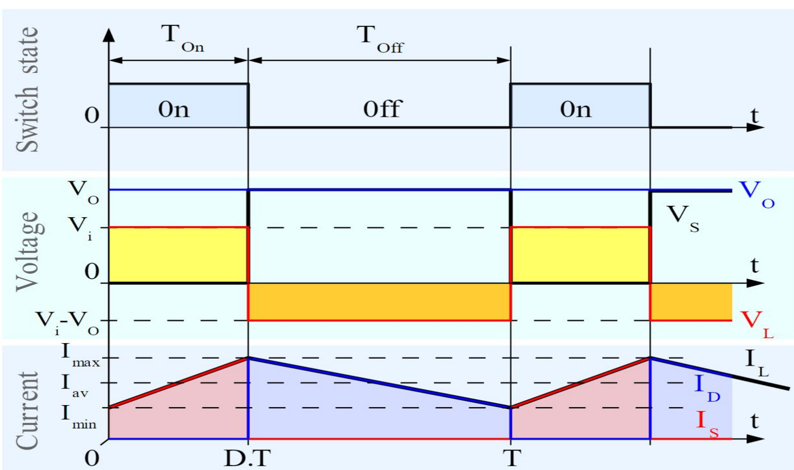


Figure: 3

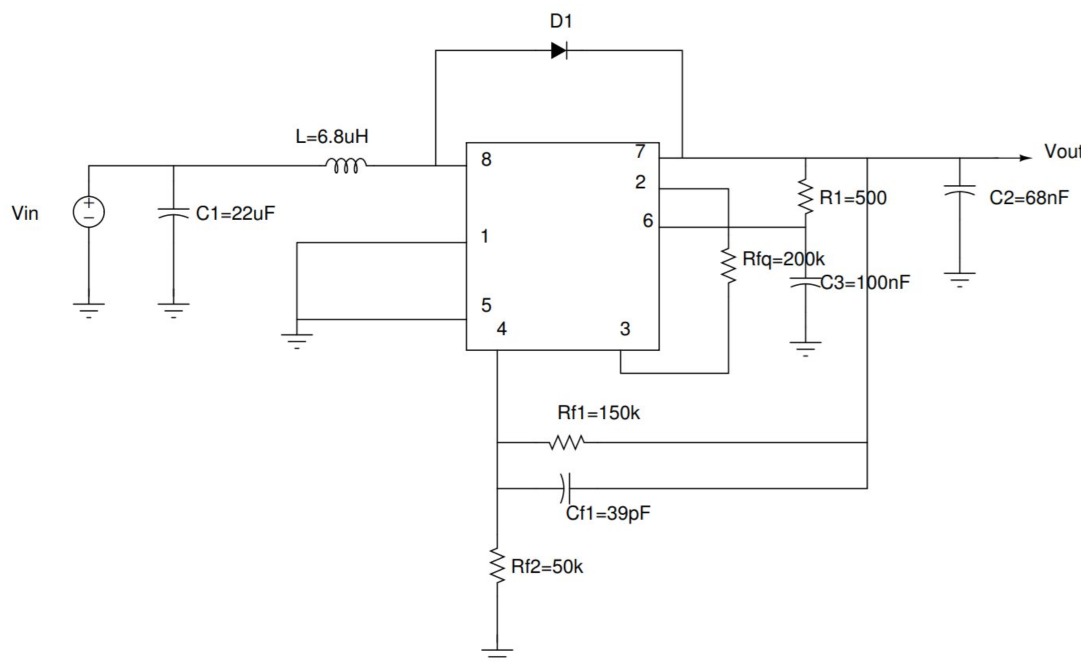
2.2 AC to DC Converter

The energy harvested from the vibrations are AC in nature.
But we need a constant DC voltage for charging the cell phone, so we need an AC to DC convertor ,a bridge rectifier. It does this using an arrangement of diodes that force the current to pass through the load in one direction only. The large capacitor filters out the ripples to give smooth DC voltage.

Chapter 3: Project Implementation

For our boost switching regulator circuit implementation, by and large we need inductor, diode, capacitor and a controller switch.
At first we thought of building our own switching control circuit, but we were unable to find way to build that. So we switched to the readymade switch LM2621 IC for our project. Here is the design of the circuit with the switch.

3.1 Switching Regulator circuit Design



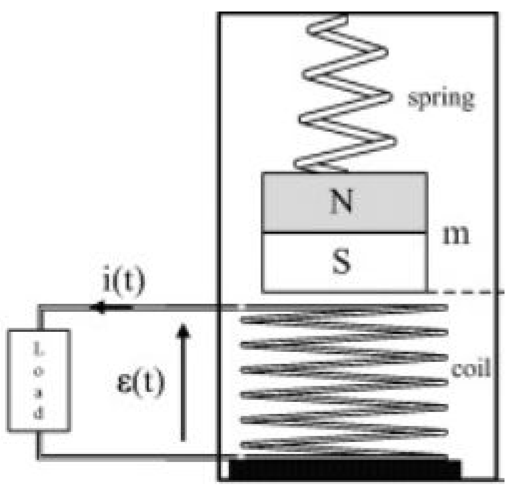
The IC lm2621 is working as switch, which uses the reference voltage according to output voltage through feedback resistor.
Advantages of this switch-
-It provides high switching frequency upto 2 Mhz and can be adjust using the Rfrq resistor.
-Due to the this much of switching frequency we can use tiny surface mount inductors and capacitors.

Relation of Vout-
Rf2 = Rf1/[(Vout/1.24) - 1]

3.2 Vibration Block

Key Principle:
Faraday's law states that the EMF is also given by the rate of change of the magnetic flux.

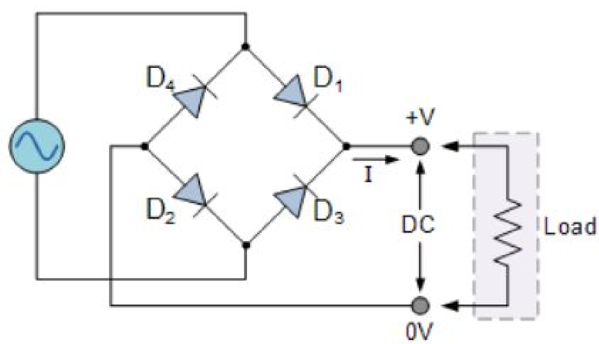
So in other words whenever there will be the vertical vibration, the magnet attached to the spring will oscillate into the magnetic coil. Since due to the magnets there will be the magnetic field and when this magnet goes inside and outside the coils, the magnetic flux will change and this result into the emf induced into the coil.
Basic figure of this setup as-



Here we can see that the voltage induced in the coil will be AC so we need an AC_DC converter which we described in the next section and the output of that converter will goes again to the DC_DC converter(setup).

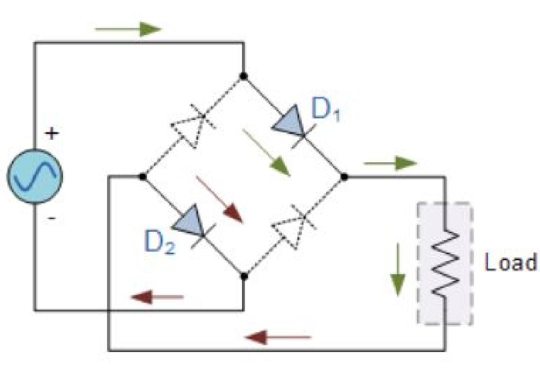
3.3 AC to DC Converter

The main advantage of this bridge circuit is that it does not require a special centre tapped transformer, thereby reducing its size and cost. The single secondary winding is connected to one side of the diode bridge network and the load to the other side.



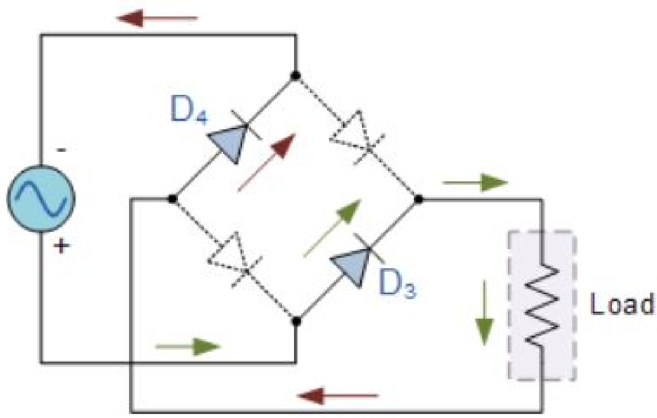
The positive half-cycle-

The four diodes labelled D1 to D4 are arranged in "series pairs" with only two diodes conducting current during each half cycle. During the positive half cycle of the supply, diodes D1 and D2 conduct in series while diodes D3 and D4 are reverse biased and the current flows through the load as shown below.



The negative half-cycle-

During the negative half cycle of the supply, diodes D3 and D4 conduct in series, but diodes D1 and D2 switch “OFF” as they are now reverse biased. The current flowing through the load is the same direction as before.



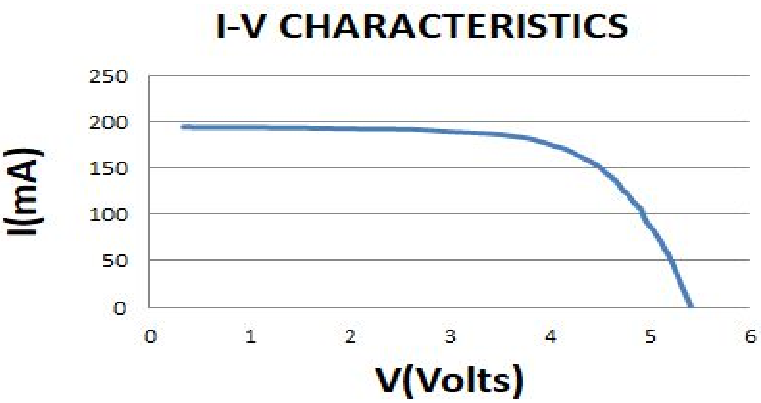
A Capacitor with the load connected to reduce the ripples and to block the ac voltage.

Chapter 4: Performance Evaluation

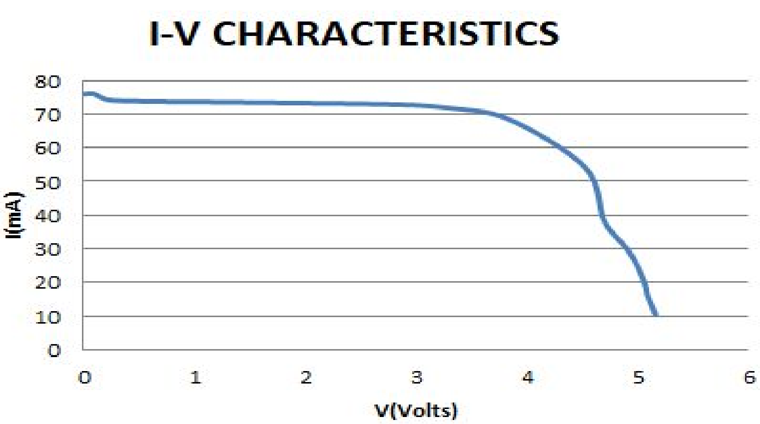
4.1 Test results

- **Characterization of our solar cell**

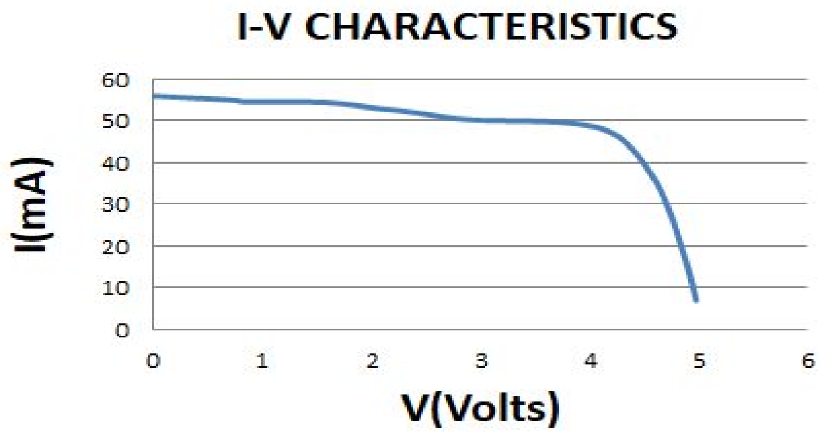
Max intensity at rooftop(mid noon)



Low intensity evening sunlight



With light bulb



- ## Circuit Testing:

4.2 Loading 2 different mobile phones in high intensity sunlight

(1 solar cell)

1.) Phone1

Solar Panel Side: I_in = 167.3 mAmp
V_in = 1.7V
P_in = 0.28W

Switching circuit Output:
I _out = 46 mAmp
V_out = 4.2V
P_out = 0.1932W

2.) Phone 2

Solar Panel Side: I_in = 164 mAmp
V_in = 1.53V
P_in = 0.25W

Switching circuit Output:
I _out = 44.2 mAmp
V_out = 4.37V
P_out = 0.192W

Loading 2 different mobile phones in high intensity sunlight

(2 solar cells in parallel)

2.) Phone1

Solar Panel Side: I_in>200 mAmp
V_in = 1.97V
P_in >0.4W

Switching circuit Output:
I _out = 74 mAmp
V_out = 4.1V
P_out = 0.304W

2.) Phone 2

Solar Panel Side: I_in >200 mAmp
V_in = 2.05V
P_in > 0.4W

Switching circuit Output:
I _out = 70.9 mAmp
V_out = 4.47V
P_out = 0.313W

VIBRATIONAL BLOCK TESTING

Ipk-pk(mAmp)	Vpk-pk(Volts)
0	8(Voc)
6-7	6-7
20	1

4.3 Problem Faced

One challenge was to regulate the voltage at constant 5V because the current supplied by the solar panel was very small.
Other and the most difficult challenge was to harvest vibrational energy. Conversion of vibrational energy to mechanical was very inefficient and we could hardly extract any energy compared to the solar energy harvested.

Chapter 5: Conclusion and suggestions for future work

5.1 Conclusions

This design or project is for charging mobile phones and other gadgets by using solar energy and vibrational energy. The design will be quite effective in providing an alternate means of power supply for the mentioned devices during emergency. This system can be used to charge any gadget which supports rechargeable battery. It is not confined to only mobile phones. Further, the approach presented in this paper can be extended to many other applications.

5.2 Scope in Future

We know very well that the developing countries like India has no any laws for population control. Population is increasing with rate 20 % decadely but the resources are finite and limited. Forest land is reducing eventually, mining is going on, fertile lands is reducing. Pollution is on its peak ,so we need other sources of energy which is not limited and unutilised. Solar energy is one of them. So we must try getting power from these sources.Vibration or movement is present everywhere ,so we can use this unutilised energy.
In future, we might be able to efficiently harvest vibrational energy.