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Design of an Energy Efficient Eco-Friendly Mobile Charger Usable in All Terrains

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ABSTRACT: Mobile charger is a household device. Even solar powered mobile chargers are available in market. However reliability and efficiency of these chargers are questionable. After conducting market survey we found most of the solar charger are not reliable and in efficient and very costly. Thus common people cannot afford them. Thus we thought of designing a solar charger which will work on battery, power supply and solar power, thus enabling us to use it any place at any time. This will also save our money from buying costly power banks. Our motto is to make a industrial device which will find its usage in every household, even in the remotest of places where electricity is not available.

KEY WORDS: Cell phone-Cellular phone. IC-Integrated Circuit, CFR-carbon film Resistor.

I. INTRODUCTION

Solar Mobile range of environmentally friendly power chargers means running out of power mid-conversation or half way through one's favorite track on his phone will become a thing of the past; even if one is kilometers from the nearest power socket. Solar Mobile's powerful solar panels have been specially designed to draw in the sun's rays, harnessing their energy and storing it for up to three months. So even when the sun's not shining, this energy-saving gem of a device will come to the rescue, rejuvenating your powerless portable gadgets and getting one back on track with his conversations, music, games and movies: even if one is in the middle of nowhere. Solar powered cell phone chargers [2] can be a better alternative to electrical cell phone chargers. One has to plug in his cell phone to a home outlet and then he has to wait a long time for the cell phone to be charged. The charging of cell phone takes electricity and the electricity costs money. It seems that one needs to pay for his mobile cell phone service provider for using cell phone and he also has to pay the electric company for using his cell phone. General Rule to estimate total hours of direct sunlight to full charge: (Ampere per Hour of the Battery / Amperes per Hour of the Charger) + 10%Assuming one has a 5 Watt / Hour Cell Phone Battery (like the one of Sony Ericsson Kurara, Nokia N900 or Razr V3) and a 2 Watt output solar Charger, one needs first to convert Watt in Ampere: Ampere= Watt/Volts. It's about 5/12 = 0.417 Amperes per hours for the battery and 0.167 Amperes for the charger.

To calculate how much time is needed to charge the battery with a 2 Watt solar charger one has to calculate the Ampere per hour of the charger: 2 Watts /12 Volts = 0.167 Amperes 2° Divide 0.417 amp hours (cell phone battery) / 0.167 amperes (solar charger) = 2.50 Hours of direct sunlight to full charge the cell phone Battery .To get the practical value one has to add 10% extra i.e. 2.75 hours. Result: One will need an average of 3 hours of direct sunlight to full charge his cell phone battery using a 2 Watt solar charger or 30 minutes if he has one charger of 18 Watt capacity. Although great strides have been made in the area of solar energy and turning that energy into viable power for residential and commercial purposes, there is still a great deal to test and discover. Who wouldn't want to use an environmentally friendly solar powered mobile phone? The idea of a solar cell phone charger is an excellent one in that it's meant to allow for an option for charging the phone when one is in a remote area or just does not has access to an electrical outlet or car charger.

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II. STYLES OF MOBILE PHONE CHARGERS

The designs of the solar chargers on the market today[1] are as varied as the styles of mobile phones being used every day around the world.

1. Windmill design three panels that fan out to catch as much sun as possible
2. Folding compact and lightweight, this style of cell phone charger opens up to reveal anywhere from 2 to 4 solar panels that will charge not only your phone, but iPod, MP3 player, and more
3. Pocket charger compact enough to fit into your pocket, it's great for providing emergency backup power to your cell phone in the case of emergency and is good for roughly 45 minutes

These are just a few of the styles available to the public, but each has its own set of features and capabilities.

III. BENEFITS OF SOLAR MOBILE CHARGERS

Cell phones can be a real lifesaver in emergency situations. People have come to depend on this technology greatly over the last few years. Technologies such as iPods, MP3 players, and hand-held games have also become quite popular. All of these require fully charged batteries to function at their optimal level. Solar chargers are great for those times you are not close to a power source. Another benefit of these chargers is that they're free to use since they use the sun's energy. The backup battery stores energy even when it's not actively charging, so you can enjoy more time in between having to charge your cell phone battery via electric.

IV. SOME DISADVANTAGES OF SOLAR MOBILE CHARGERS

There are some disadvantages to cell phone chargers powered by the sun. The most obvious of course is that if it's a cloudy or overcast day, your solar powered charger isn't going to be able to garner the energy it needs from the sun in order to function. Usually, it needs direct sunlight[3] in order to store enough in the battery to work efficiently.
Another disadvantage to the current solar phone chargers is that the amount of power they are capable of generating isn't always enough to keep up with the amount of power required by today's highly functional cell phones. Some analysts say that in order to meet and exceed the power needs of most cell phones, the solar cell phone charger will have to be larger in order to capture more of the sun's energy more quickly. However, this poses a devices and anything requiring electricity. However, with the invention of solar panels and night, sometimes never taking time to unplug the electricity draining charger [4]. By utilizing solar cell phone chargers, the potential of wasting electricity and money is eliminated because the standard chargers can be stored away. Depending on the wattage of the solar cell phone charger, to fully charge a cell phone can take anywhere from thirty minutes to three hours. Because every phone is different in terms of battery life and charger times, there is an equation that can determine the time it takes by using information for the specific cell phone. Taking both amperes per hours and dividing the number for the battery by the charger, and then multiplying by an additional ten percent will equal the hours required for a full charge. From busts to stars, the range of quality in solar cell phone chargers [6] is quite heavy.

V. GENERAL OVERVIEW OF SOLAR CELL PHONE CHARGERS

The new great investment to make is solar mobile phone chargers. With their ability to eliminate the need of standard chargers and wall outlets, along with preserving the environment, picking one of these devices up can be of huge value and use. The simplicity of this product and incredible benefit it provides for people in charging a cell phone anywhere is priceless. Whether someone is stranded, camping, or out of wall outlets, a solar cell phone charger can make all the difference. Until the past few years, the sun has been overlooked in the ability to produce energy for appliances.

VI. BASICS OF SOLAR CELLS

Solar cells are often electrically connected and encapsulated as a module. Photovoltaic modules often have a sheet of glass on the front (sun up) side, allowing light to pass while protecting the semiconductor [2]wafers from abrasion and impact due to wind-driven debris, rain, hail, etc. Solar cells are also usually connected in series in modules, creating an additive voltage. Connecting cells in parallel will yield a higher current; however, very significant problems exist

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with parallel connections. For example, shadow effects can shut down the weaker (less illuminated) parallel string (a number of series connected cells) causing substantial power loss and even damaging the weaker string because of the excessive reverse bias applied to the shadowed cells by their illuminated partners. Strings of series cells are usually handled independently and not connected in parallel, special paralleling circuits are the exceptions. Although modules can be interconnected to create an array with the desired peak DC voltage and loading current capacity, using independent MPPTs (maximum power point trackers) provides a better solution.
The efficiency of a solar cell may be broken down into reflectance efficiency, thermodynamic efficiency, charge carrier separation efficiency and conductive efficiency. The overall efficiency is the product of each of these individual efficiencies. A solar cell usually has a voltage dependent efficiency curve, temperature coefficients, and shadow angles. Due to the difficulty in measuring these parameters directly, other parameters are measured instead: thermodynamic efficiency, quantum efficiency, integrated quantum efficiency, VOC ratio, and fill factor. Reflectance losses are a portion of the quantum efficiency under "external quantum efficiency". Recombination losses make up a portion of the quantum efficiency, VOC ratio, and fill factor. Resistive losses are predominantly categorized under fill factor, but also make up minor portions of the quantum efficiency, VOC ratio.
High-efficiency solar cells are of interest to decrease the cost of solar energy. Many of the costs of a solar power plant are proportional to the panel area or land area of the plant. A higher efficiency cell may reduce[8] the required areas and so reduce the total plant cost, even if the cells themselves are more costly. Efficiencies as shown in the Figure-1of bare cells, to be useful in evaluating solar power plant economics, must be evaluated under realistic conditions. The basic parameters that need to be evaluated are the short circuit current, open circuit voltage.

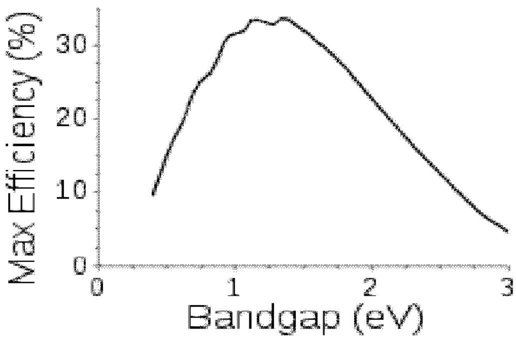

Figure-1: Maximum Efficiency of a solar

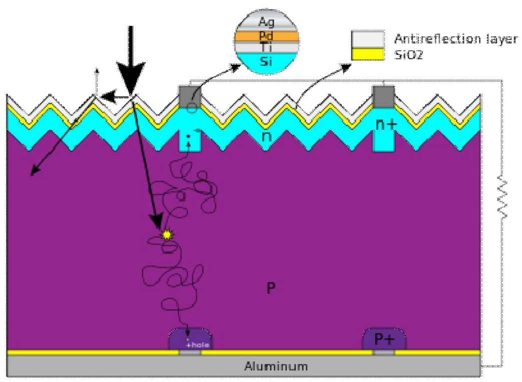

Figure-2: Basic structure of a silicon based solar cell and its working mechanism. Courtesy-Wikipedia [7].

V. DESIGN CONCEPT

A general purpose and truly versatile mobile charger must be compact and efficient besides being eco-friendly. A person can travel to mountains, go for a rowing, travel in trains and may remain outdoors[15] where sunlight may or may not be available and even 230V AC power socket is absent. The mobile charger should be able to charge his mobile and help him remain connected. This has been the criterion of this design exercise

The Shockley-Queisser limit for the theoretical maximum efficiency of a solar cell semiconductors with band gap between 1 and 1.5eV, or near-infrared light, have the greatest potential to form an efficient cell. (The efficiency "limit" shown here can be exceeded by multi-junction solar cells[16].)Various materials display varying efficiencies and have varying costs. Materials for efficient solar cells must have characteristics matched to the spectrum of available light. Some cells are designed to efficiently convert wavelengths of solar light that reach the Earth surface. However, some solar cells[5] are optimized for light absorption beyond Earth's atmosphere as well. Light absorbing materials can often be used in multiple physical configurations as shown in the Figure-2 to take advantage of different light absorption and charge separation mechanisms(7). Materials presently used for photovoltaic solar cells include monocrystalline silicon, polycrystalline silicon, amorphous silicon, cadmium telluride, and copper indium selenide /sulfide. Many currently available solar cells are made from bulk materials that are cut into wafers between

180 to 240 micrometers thick that are then processed like other semiconductors. Other materials are made as thin-films layers, organic dyes, and organic polymers that are deposited on supporting substrates. A third group are made from nano crystals and used as quantum dots (electron-confined nano-particles). Silicon remains the only material that is well-researched in both bulk and thin-film forms.

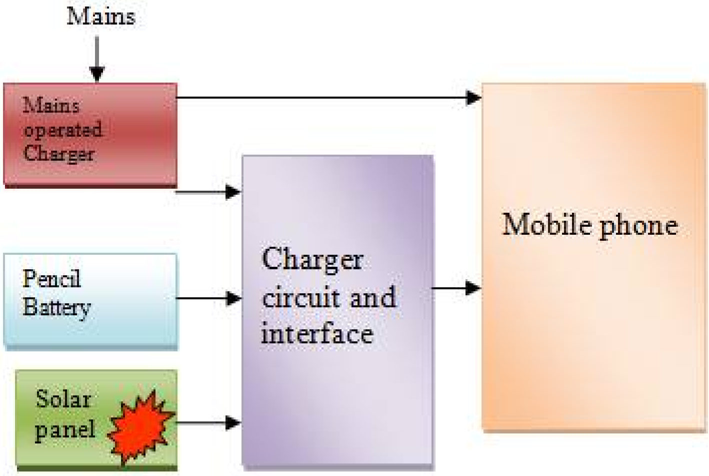

Figure-3: Block diagram of mobile charger.

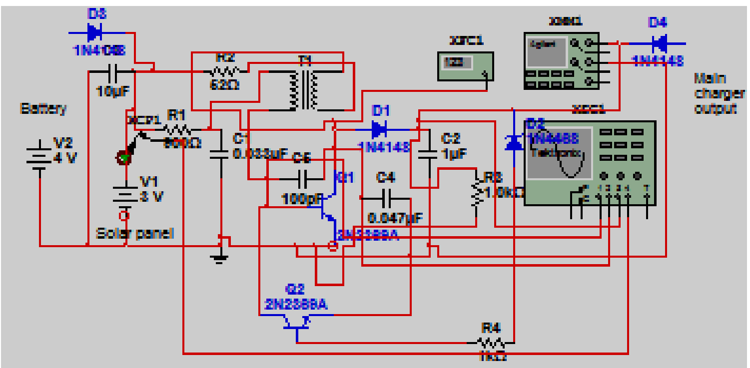

Figure-4: Circuit diagram of mobile charger

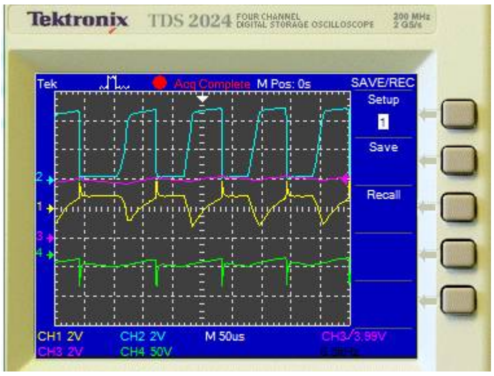

Figure-5: Wave forms during simulation/testing Yellow-Base[of Q1]trigger;Blue-Q1Collector wave form; pink-DC output voltage; Green- current through the solar cells.

VI. CIRCUIT DESCRIPTION

The circuit is a single transistor oscillator called a feedback oscillator, or more accurately a BLOCKING OSCILLATOR. It has 45 turns on the primary and 15 turns on the feedback winding. Actually there is no secondary as the primary produces a high voltage during part of the cycle and this voltage is delivered to the output via a high-speed diode to produce the desire output. The output voltage consists of high voltage spikes and should not be measured without a load connected to the output. The transistor is turned on via the 1K base resistor. This causes current to flow in the primary winding and produce magnetic flux. This flux cuts the turns of the feedback winding and produces a voltage in the winding that turns the transistor ON more. This continues until the transistor is fully turned ON and at this point, the magnetic flux in the core of the transformer is at maximum. But is not EXPANDING FLUX, It is STATIONARY FLUX and does not produce a voltage in the feedback winding. Thus the "turn-on" voltage from the

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feedback winding disappears and the transistor turns off slightly (it has the "turn-on effect of the 1K resistor). The magnetic flux in the core of the transformer begins to collapse and this produces a voltage in the feedback winding that is opposite to the previous voltage. This has the effect of working against the 1K resistor and turns off the transistor even more. The transistor continues to turn off until it is fully turned off. At this point the 1K resistor on the base turns the transistor on and the cycle begins. At the same time, another amazing thing occurs. The collapsing magnetic flux is producing a voltage in the primary winding. Because the transistor is being turned off during this time, we can consider it to be removed from the circuit and the winding is connected to a high-speed diode. The energy produced by the winding is passed through the diode and appears on the output as a high voltage spike. This high voltage spike also carries current and thus it represents ENERGY. This energy is fed into the load and in our case the load is a battery being charged. The clever part of the circuit is the high voltage produced. When a magnetic circuit collapses (the primary winding is wound on a ferrite E-E cores, and this is called a magnetic circuit), the voltage produced in the winding depends on the QUALITY of the magnetic circuit and the speed at which it collapses. The voltage can be 5, 10 or even 100 times higher than the applied voltage and this is why we have used it. This is just one of the phenomenon of a magnetic circuit. The collapsing magnetic flux produces a voltage in each turn of the winding and the actual voltage depends on how much flux is present and the speed of the collapse.
Following table -I furnishes the design equations of various current components.Figure-4 describes the charger circuit while Figure-6 depicts the entire circuitry. Table-II lists the BOM and costing per unit.

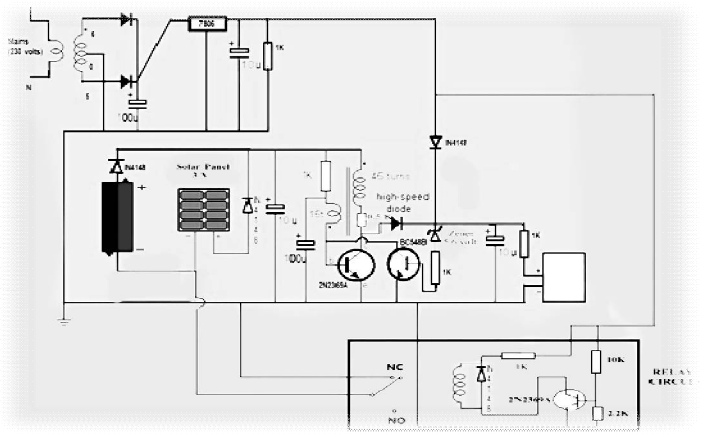

Figure-6: Full circuit diagram.

Table-I: Main design equations

Peak inductor current	i_{pk}
Min inductor current	i_o
Ripple Current	$\Delta i \equiv (i_{pk} - i_o)$
Ripple Current Ratio to Average Current	$r \equiv \Delta i / i_{ave}$
Off Duty Cycle	$1 - D \equiv T_{off} / T$
Switch Off Time	$T_{off} = (1 - D)/f$
Average and Load Current	$i_{ave} \equiv \Delta i/2 \equiv i_{load}$
RMS Current for a Triangular Wave	$i_{rms} = \sqrt{i_o^2 + (\Delta i)^2 / 12}$

ipk : peak current,io=DC current,T=Time period,D=Duty cycle,iavg = average current,irms=rms current,Toff=Off time.

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VII. LIST OF COMPONENTS AND COSTING.

Table-II: Bill of Materials and costing.

Component Name	*No of Component*	*Unit price in Rs*	*Total Price in Rs*
Resistance, 1k,CFR.1/4,1/4w	3	0.1	1.0
Capacitance, 10uF,25V	3	5.0	15.0
Capacitance, 100uF,25V	2	5.0	10.0
Diode, IN4148	4	1.0	4.0
Diode,1N4007	4	2.0	8.0
IC,uA7806	1	20	20.0
Trans former,230V;6-0-6V@100mA	1	30	30.0
Zener Diode, 5.6V	1	1.0	1.0
Transformer,15:45turns	1	30	30.0
Transistor, 2N2369A	1	5.0	5.0
Transistor, BC548B	1	5.0	5.0
Solar Panel, V o/p,4.0V	1	300	300.0
Normal charger circuit	1	400	400.0
Pencil Battery	2	15.0	15.0
Wires,chords,battery holder		10.0.0	10.0
Vero board	1	25.0	25.0

Total cost in Rupees **879.0/-**

VII. TEST METHODOLOGY

Short Circuit Current (ISC) – This is the maximum current that the cell can provide and it occurs when the cells is short circuited. Unlike other small scale electricity generating systems PV cells are not harmed by being shorted out.

A. TESTING OF SOLAR PANEL.

I. Open circuit Current (VOC) – This is the maximum voltage that exist between the cells terminals and is obtained when there is no load connected across them.
II. Maximum Power Point (PMax) – The point on the I-V curve[9] at which maximum power is being produced by the cell. It may be noted that since the graph is not a straight line, the power[14] produced will vary depending on the operating voltage (figure -7); although the voltage at any point on the graph can still be calculated using P=I*V. PMax occurs on the 'knee' of the I-V curve.

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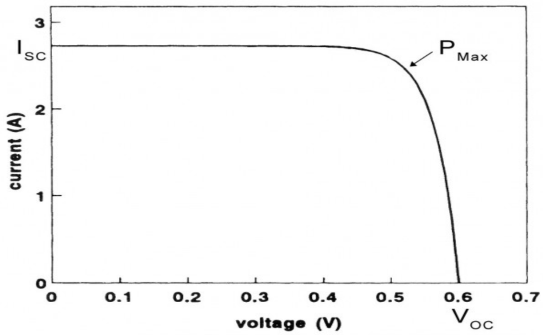

Figure-7: I-V Curve of the Solar Cell, Courtesy Wikipedia [7]

B. OPEN CIRCUIT TEST

Table-III: Data of Open circuit test for solar panel

TIME	VOLTAGE(volt)
8:00:00 AM	3.2
10:00:00 AM	3.5
12 NOON	3.5
4 PM	3.24
6 PM	1.2

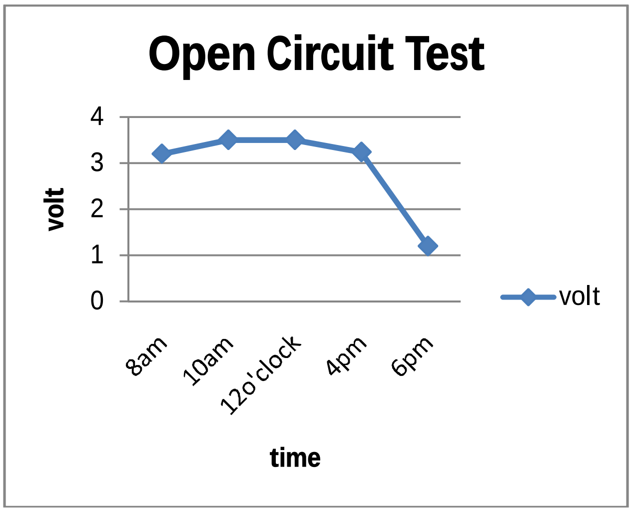

Figure-8. Open circuit test

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C. SHORT CIRCUIT TEST

Table-IV: Data of Short circuit test on solar panel

TIME	CURRENT(mA)
8:00:00 AM	138
10:00:00 AM	180
12 NOON	200
4 PM	135
6 PM	5

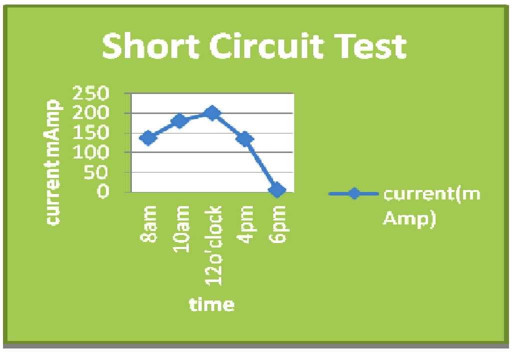

Figure-9: Graph of Short circuit test

Table-V: Data of I-V of Solar panel[10] at 11am. [Load current test]

CURRENT (mA)	VOLTAGE (volts)
0	3.15
32	3
40	2.8
67	2.7
Short circuit	0

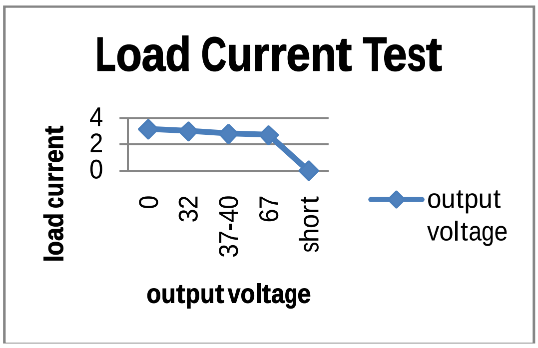

Figure-10: Load current test.

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III. TESTING OF THE CHARGER CIRCUIT.

The prototype was tested with 2 Nos of 1.5V pencil battery, solar panel and the mains charger circuit selected through DIP switch mounted on the charger board. If mains are connected pencil battery and solar panel are automatically disconnected by a DIP reed relay. Tests set ups are shown in the Figure-11.Prototype is shown in the figure-12.

(a) Mobile charging wave form at 3.10 Volts (b)Wave form at 2.93V (c) Wave form at 3.11V

Figure-11: Actual test bench set ups.

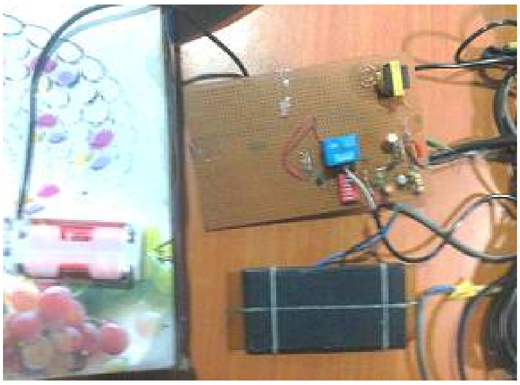

Figure-12: Prototype

Table-VI: Final results

Srl	Input	Input voltage	Output Volts	Remarks
1	Pencil Battery-[B]	3.10V; S,M-off	5.21	Charging the mobile
2	Solar pane –[S]	2.9V;B, M-off	5.15	Charging the mobile
3	Mains-[M]	B,S-off	6.00	Charging the mobile

VIII. CONCLUSION

In a developing country like ours, energy crisis is going to compound due to rapid depletion of fossil fuels. Complete independence from the conventional energy sources is not possible overnight. It is therefore necessary to reduce dependence and utilise alternate renewable [11] sources judiciously wherever and whenever possible. In housing and Industrial establishments, switching to alternate sources of energy[14] is possible under the supervision of microcontrollers as soon and as much of such possibility available. Following work areas open up for further investigations on efficient energy planning:

[1] Energy planning.
[2] Installation of alternate energy [12] sources.
[3] Intelligent utilisation of the resources for reducing dependence on fossil fuels.
[4] Continuous review of energy options and their application through fine tuning of programs in embedded systems.

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[4]http://www.echarger.c.uk/solarmobile-html
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