Solar Power Mobile Charger Using Buck Converter

A Project report submitted in partial fulfilment

of the requirements for the degree of B. Tech in Electrical Engineering

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CERTIFICATE

To whom it may concern

This is to certify that the project work entitled **Solar Power Mobile Charger Using Buck Converter** is the bona fide work carried out by **Sujan Gain (11701615060), Adarsha Rana (11701615002),Manish Kumar (11701615019)** , a student of B.Tech in the Dept. of Electrical Engineering, RCC Institute of Information Technology (RCCIIT), Canal South Road, Beliaghata, Kolkata-700015, affiliated to Maulana Abul Kalam Azad University of Technology (MAKAUT), West Bengal, India, during the academic year **2018-19**, in partial fulfillment of the requirements for the degree of Bachelor of Technology in Electrical Engineering and that this project has not submitted previously for the award of any other degree, diploma and fellowship.

______________________ ______________________

Signature of the Guide **Signature of the HOD**

Name: **Name:**

Designation **Designation**

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Signature of the External Examiner

Name:

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Full Signature of the Student

Place:

Date:

ABSTRACT

In almost all the countries mobile phones is the most popular form of communication. The number of mobile users will surpass 7.6 billion this year (2018) and the number is growing as technology is getting better and the cost of production also lowers. However it becomes very inconvenient for persons occupied with work or travelling long distances as the average lifetime of a mobile phone battery is less than 10 hours. Solar phone chargers use small solar panel to absorb light. This process still forces customers to carry another device along with their cell phone. And also the proposed system, solar powered charger (SPC) plays an important role in mobile charging during travelling. The sun is the ultimate power source and solar energy is renewable energy source. The SPC system is ecofriendly and user friendly. The solar panel used is of 10v rating. The voltage must be suitably step down. So we designed a small charger panel, getting the appropriate voltage and power output through a DC-DC step-down buck converter. We designed a final prototype that should be able to charge any of the commonly used local phones in 10-12 hours of direct sunlight.

CHAPTER 1: ENABLING TECHNOLIGIES FOR SOLAR POWER MOBILE CHARGER USING BUCK CONVERTER

1.1 INTRODUCTION

Solar energy is the energy produced directly by the sun and collected elsewhere, normally the Earth. The sun creates its energy through a thermonuclear process. The process creates heat and electromagnetic radiation.

Only a very small fraction of the total radiation produced reaches the Earth. The radiation that does reaches the Earth is the indirect source of nearly every type of energy used today. The radiation that does reach the Earth is the indirect source of nearly every type of energy used today. The exceptions are geothermal energy, and nuclear fission and fusion. Even fossil fuels owe their origins to the sun; they were once living plants and animals whose life was dependent upon the sun.

Much of the world's required energy can be supplied directly by solar power. More still can be provided indirectly. The practicality of doing so will be examined, as well as the benefits and drawbacks. In addition, the uses solar energy is currently applied to will be noted.

Due to the nature of solar energy, two components are required to have a functional solar energy generator. These two components are a collector and a storage unit. The collector simply collects the radiation that falls on it and converts a fraction of it to other forms of energy (either electricity and heat or heat alone). The storage unit is required because of the non-constant nature of solar energy; at certain times only a very small amount of radiation will be received. At night or during heavy cloud cover, for example, the amount of energy produced by the collector will be quite small. The storage unit can hold the excess energy produced during the periods of maximum productivity, and release it when the productivity drops. In practice, a backup power supply is usually added, too, for the situations when the amount of energy required is greater than both what is being produced and what is stored in the container.

1.2 PURPOSE OF THIS PROJECT

Our main purposes of this project are mentioned bellow –

1. There are some remote areas of India that have not yet reached the electrification. In these remote areas using this solar power mobile charger, people can charge mobile phones and some USB devices effortlessly and without the use of electricity.
2. Solar energy comes in free of charge. The energy from the sun is free. The source of energy is practically free because we get sunlight directly from sun.
3. Solar Energy is an Eco friendly and renewable energy. So it does not have any natural pollution.
4. Its cost is less and once it is installed, it offers a lot of benefits.
5. The cost of maintenance is very few.
6. By the store of this energy in batteries and we will be able to run different USB devices (like USB fan, USB light etc.) later on.
7. It also helps reduces cost such as electric bills as the solar charger source of energy is free.
8. The solar charger also operates quietly and this does not contribute to noise pollution.

1.3 PHOTOVOLTAIC CELL

The term "photovoltaic" comes from the Greek (photo) means "light", and "voltaic", means electric ,from the name of the Italian physicist “VOLTA "after whom a unit of electro-motive force, the volt is named. The sun is a star made up of hydrogen and helium gas and it radiates an enormous amount of energy every second. A photovoltaic cell is an electrical device that converts the energy of light directly into electricity by photovoltaic effect. Photovoltaic is the field of technology and research related to the practical application of photovoltaic cells in producing electricity from light, though it is often used specifically to refer to the generation of electricity from sunlight. Cells can be described as photovoltaic even when the light source is not necessarily sunlight (lamplight, artificial light, etc.). In such cases the cell is sometimes used as a photo detector (for example infrared detectors, detecting light or other electromagnetic radiation near the visible range, or measuring light intensity. The operation of a photovoltaic (PV) cell requires 3 basic attributes:

The absorption of light, generating either electron-hole pairs or exactions.

The separation of charge carriers of opposite types.

The separate extraction of those carriers to an external circuit.

In contrast, a solar thermal collector collects heat by absorbing sunlight, for the purpose of either direct heating or indirect electrical power generation. "Photo electrolytic cell" (photo electrochemical cell), on the other hand, refers either a type of photovoltaic cell (like that developed by A.E. Becquerel and modern dye-sensitized solar cells or a device that splits water directly into hydrogen and oxygen using only solar illumination.

Photovoltaic power generation employs solar panels composed of a number of solar cells containing a photovoltaic material.
Materials presently used for photovoltaic include monocrystalline silicon, polycrystalline silicon, amorphous silicon, cadmium telluride, and copper indium gallium selenite/sulphide. Due to the increased demand for renewable energy sources, the manufacturing of solar cells and photovoltaic arrays has advanced considerably in recent years.

Solar photovoltaic are a sustainable energy source. By the end of 2011, a total of 71.1 GW had been installed, sufficient to generate 85 TWh/year. And by end of 2012, the 100 GW installed capacity milestone was achieved.

Solar photovoltaic is now, after hydro and wind power, the third most important renewable energy source in terms of globally installed capacity. More than 100 countries use solar PV. Installations may be ground-mounted (and sometimes integrated with farming and grazing) or built into the roof or walls of a building (either building-integrated photovoltaic or simply rooftop).

Driven by advances in technology and increases in manufacturing scale and sophistication, the cost of photovoltaic has declined steadily since the first solar cells were manufactured, and the liveliest cost of electricity (LCOE) from PV is competitive with conventional electricity sources in an expanding list of geographic regions. Net metering and financial incentives, such as preferential feed-in tariffs for solar-generated electricity, have supported solar PV installations in many countries. With current technology, photovoltaic recoup the energy needed to manufacture them in 3 to 4 years. Anticipated technology would reduce time needed to recoup the energy to 1 to 2 year.

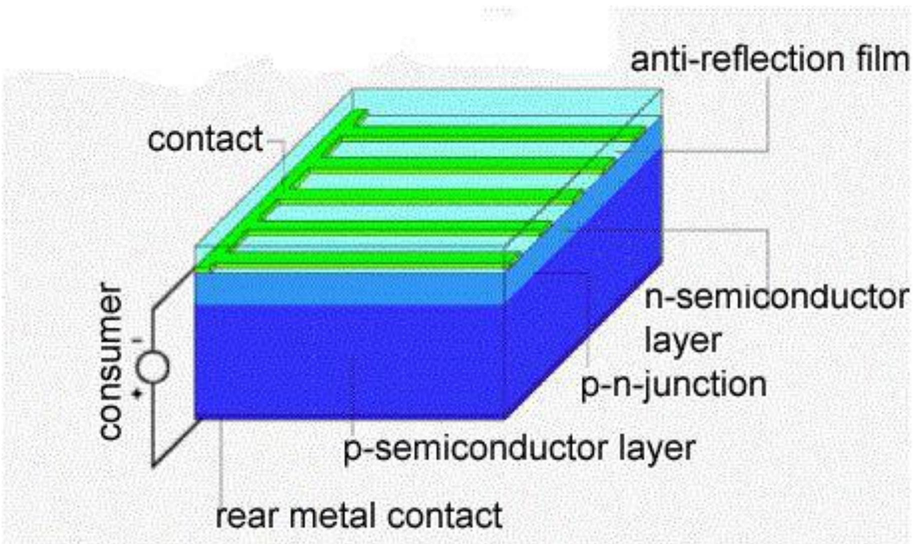

Fig. 1 - Solar Cell

1.4 SOLAR PROCESS

Photovoltaic cells are made of special materials called semiconductors such as silicon. An atom of silicon has 14 electrons, arranged in three different shells.

The outer shell has 4 electrons. Therefore a silicon atom will always look for ways to fill up its last shell, and to do this, it will share electrons with four nearby atoms. Now we use phosphorus (with 5 electrons in its outer shell). Therefore when it combines with silicon, one electron remains free.

When energy is added to pure silicon it can cause a few electrons to break free of their bonds and leave their atoms. These are called free carriers, which move randomly around the crystalline lattice looking for holes to fall into and carrying an electrical current.

However, there are so few, that they aren't very useful. But our impure silicon with phosphorous atoms takes a lot less energy to knock loose one of our "extra“ electrons because they aren't tied up in a bond with any neighbouring atoms. As a result, we have a lot more free carriers than we would have in pure silicon to become N-type silicon.

The other part of a solar cell is doped with the element boron(with 3 electrons in its outer shell)to become P-type silicon.

Now, when this two type of silicon interact, an electric field forms at the junction which prevents more electrons to move to P-side.

When photon hits solar cell, its energy breaks apart electron-hole pairs. Each photon with enough energy will normally free exactly one electron, resulting in a free hole as well. If this happens close enough to the electric field, this causes disruption of electrical neutrality, and if we provide an external current path, electrons will flow through the P side to unite with holes that the electric field sent there, doing work for us along the way. The electron flow provides the current, and the cell's electric field causes a voltage.

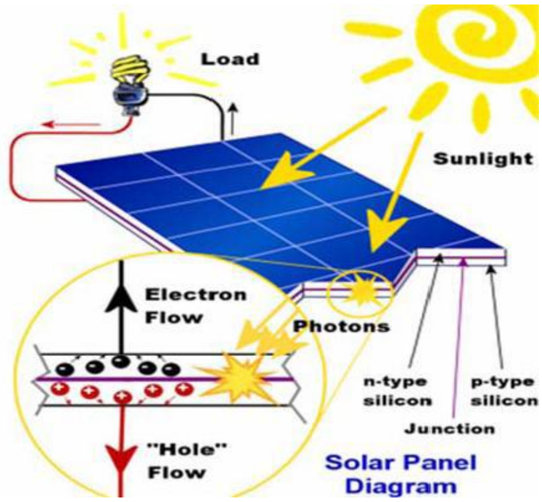

Fig. 2 - Solar Process

1.5 ADVANTAGES OF SOLAR POWER

It is estimated that in 2025, of the total world's power generation, 10% will be by solar power. The solar power is free, the sun will be shining as long as the human race is around. In one hour more sunlight falls on the earth than what is needed by the entire population in one year. So this energy needs to be harvested. The potential for the solar energy industry is huge. As more and more people begin to realize the great benefits of solar power generation, they will start to shift towards using it. Solar panels have relatively long life spans of 30-40 years and rarely need to be replaced for being faulty. They also produce as much energy over their lifetime as nuclear fuel rods without hurting the environment. Solar panels work with no moving parts which results in silence as well as a miniscule requirement for maintenance. The energy from the sun can be converted into AC power to charge devices, can be stored in batteries.

- Solar energy is a renewable energy sources.
- Solar energy comes in free of charge.
- Solar cells panel on the solar charger does not require much maintenance.
- It also helps reduces cost such as electric bills as the solar charger source of energy is free.

CHAPTER 2: BLOCK DIAGRAM

2.1 BLOCK DIAGRAM OF THE SYSTEM

The block diagram of the system contains a solar panel, buck converter and battery. The solar panel is used to convert the solar energy to electrical energy .The normal voltage rating of the solar panel used is 12V.The principle used is PHOTOELECTRIC EFFECT for the conversion of solar energy to electrical energy .When light is incident upon a material surface; the electrons present in the valence band absorb energy and get excited. They jump to the conduction band and become free. Some reach a junction where they are accelerated into a different material by a Galvani potential. This generates an electromotive force, and thus electric energy. Buck converter is a dc-dc converter, which comprises of MOSFET switch (IRF250N), inductor, capacitor and diode. Buck converter reduces the input voltage to desirable voltage of charging. Battery is charged from this output of buck converter.

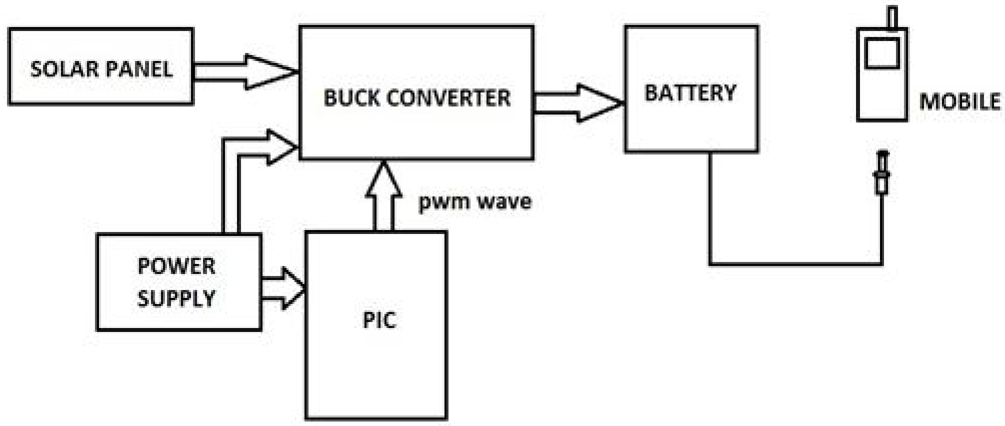

Fig. 3 block diagram of solar powered mobile charger

CHAPTER 3: PROPOSED SYSTEM HARDWARE AND ARCHITECTURE

3.1 LIST OF HARDWARE

COMPONENT NAME	SPECIFICATION	QUANTITY
1.SOLAR PANEL	POLYCRYSTALINE,OUTPUT VOLTAGE 11.4V	1
2.BUCK CONVETER	Input Voltage : 0V-35V,Output Voltage : 1.3V-30V	1
3.DC VOLTMETER	DIGITAL,0-100V DC	1
4.BATTERY	LITHIUM,3000mAH	1
5.LED	RED COLOUR	1
6.SWITCH	PIANO TYPE	3
7.POWER BANK CIRCUIT	PLC	1
8.USB CABLE	-	1
9.MICRO USB CABLE	-	1
10.CONNECTING WIRE	-	-
11.CABINET	CARDBOARD	1

3.2 DC-DC BUCK CONVERTER

`It is a dc to dc step-down converter. The simplest way to reduce the voltage of a DC supply is to use a linear regulator (such as a 7805), but linear regulators waste energy as they operate by dissipating excess power as heat. Buck converters, on the other hand, can be remarkably efficient (95% or higher for integrated circuits). It utilizes a MOSFET switch (IRFP250N), a diode, inductor and a capacitor. Few resistors also are used in the circuit for the protection of the main components. When the MOSFET switch is 'ON' current rises through inductor, capacitor and load. Inductor stores energy. When switch is 'OFF' the energy in the inductor circulates current through inductor, capacitor freewheeling diode and load. The output voltage will be less than or equal to the input voltage.

Here we use an LM2596 DC-DC buck converter step-down power module with high-precision potentiometer for adjusting output voltage, capable of driving a load up to 3A with high efficiency.

The specification of the DC-DC buck converter are-

1. Module properties : non-isolated constant voltage module
2. Rectification : non-synchronous rectification
3. Input Voltage : 0V-35V
4. Output Current : 3A maximum
5. Output Voltage : 1.3V-30V
6. Conversion efficiency : 92% (maximum)
7. Switching frequency : 150KHz
8. Output ripple : 50mV (maximum) 20M-bandwidth
9. Load regulation : ± 0.5 %
10. Voltage regulation : ± 2.5%
11. Operating temperature : -40 °C to +85 °C
12. Size : 48x23x14 mm

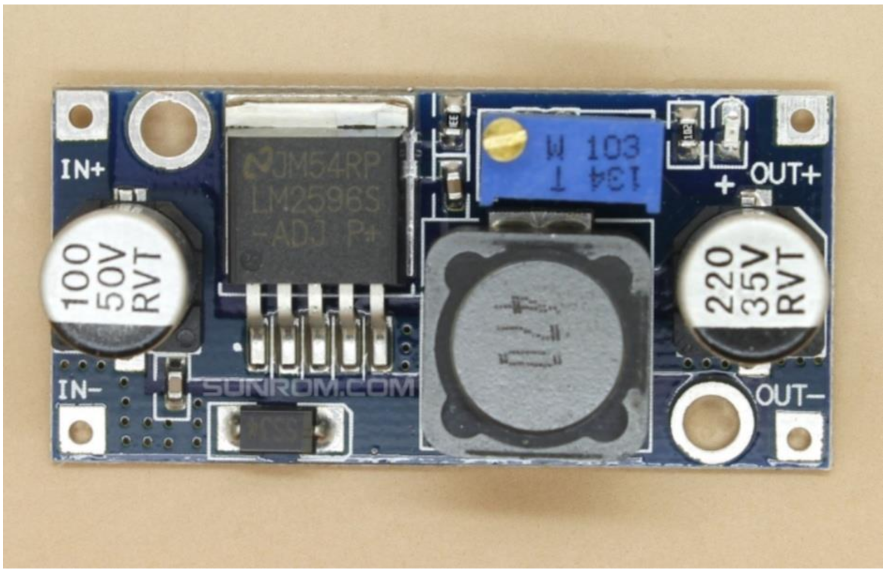

Fig. 4 - LM2596 DC-DC BUCK CONVERTER

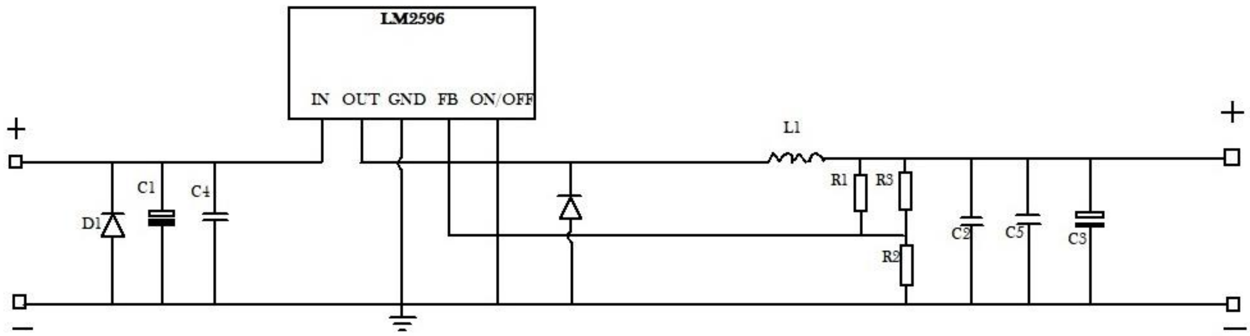

Fig. 5 - CIRCUIT DIAGRAM OF LM2596 DC-DC BUCK CONVERTER

3.3 SOLAR PANEL

A solar panel is a set of solar photovoltaic modules electrically connected and mounted on a supporting structure. A photovoltaic module is a packaged, connected assembly of solar cells. The solar panel can be used as a component of a larger photovoltaic system to generate and supply electricity in commercial and residential applications. A photovoltaic system typically includes a panel or an array of solar modules, an inverter, and sometimes a battery and/or solar tracker and interconnection wiring. Photovoltaic cells or panels are only one way of generating electricity from solar energy. They are not the most efficient, but they are the most convents to use on a small to medium scale. PV cells are made of silicon, similar to that used in computer "chips". While silicon itself is a very abundant mineral, the manufacture of solar cells (as with computer chips) has to be in a very clean environment. This causes production costs to be high. A PV cell is constructed from two types of silicon, which when hit by solar energy, produce a voltage difference across them, and, if connected to an electrical circuit, a current will flow. A number of photovoltaic cells will be connected together in a "Module", and usually encapsulated in glass held a frame which can then be mounted as required. The cells in a module will be wired in series or parallel to produce a specified voltage. What may be referred to as a 12 volt panel may produce around 16 volts in full sun to charge to 12 volt battery.

Here we use Energia company solar panel. The mechanical characteristics made from high efficiency crystalline silicon solar cells. Cells encapsulated in low iron, high transmission, toughened glass using UV stable ethylene vinyl acetate (EVA) sheets. Premium quality back sheet protect the module from environmental conditions. Laminate framed with strong anodized aluminum profile with fitted junction box.

Specification of the solar panel:

1. Material : Silicon
2. Wattage : 5W
3. Type : Polycrystalline
4. No of Cells : 18
5. Output Voltage : 11.5V
6. Dimensions : 30x20cm

Fig. 6 – Solar Panel

3.4 LITHIUM BATTERY

A typical Li-ion battery cell contains three main parts: a negative electrode, separator, and positive electrode, as shown in Figure 1. All three components are immersed in an electrolyte solution composed of a lithium salt in an organic solvent such as $LiPF_6$, $LiBF_4$, or $LiClO_4$. The negative electrode is connected to the negative terminal of the cell and usually contains graphite. The positive electrode is connected to the positive terminal of the cell and is a metal oxide or a blend of several metal oxides such as $Li_xMn_2O_4$ and Li_xCoO_2. The separator is a solid or liquid solution with a high concentration of lithium ions. It is an electrical insulator that prevents electrons from flowing between negative and positive electrodes, but the electrolyte allows ions to pass through it. In the discharging process, the lithium ions at the surface of the solid active material of the porous negative electrode undergo an electrochemical reaction, transferring the ions to the solution and the electrons to the negative terminal. The positive ions travel through the electrolyte solution to the positive electrode where they react with, diffuse toward, and are inserted into the metal oxide solid particles. Ions and electrons reverse traveling direction in the charging process. Electrochemical-based models are reasonable predictors of Li-ion battery performance and physical limitations for a wide range of operating conditions. However, the model contains coupled nonlinear partial differential equations that make it difficult for on-board applications. Thus, model reduction is necessary for real-time and control applications. Based on porous electrode theory, Li-ions can exist in a solid phase (intercalated in the electrode material) or an electrolyte phase in a dissolved state. The porous structure can be interpreted as consisting of small spherical solid particles.

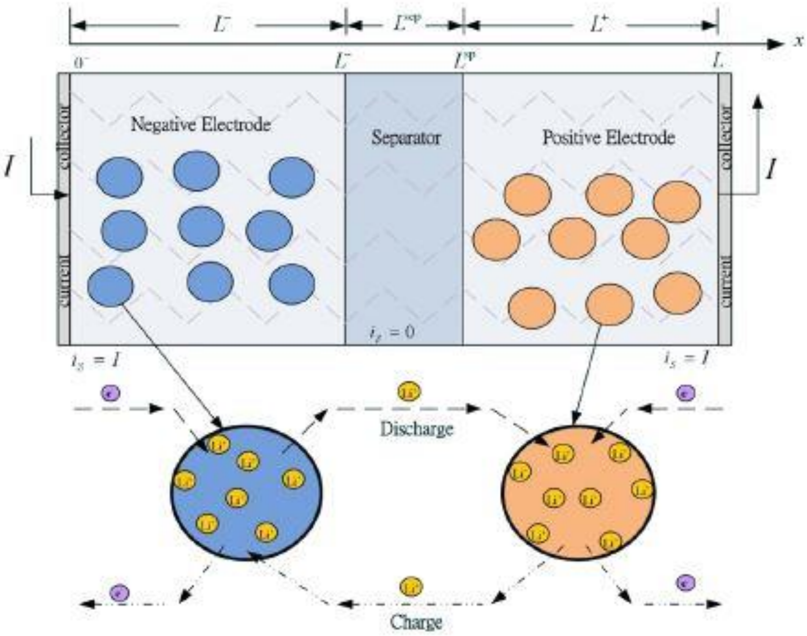

Fig. 7 - Structure of a Li-ion battery cell

Here we use Samsung brand lithium battery.

The specifications of the battery are –

1. Brand – Samsung
2. Capacity – 3000mAh
3. Type – Lithium-ion
4. Nominal Voltage – 3.85V
5. Charge voltage – 4.4V

Fig. 8 LITHIUM BATTERY

3.5 DC VOLTMETER

Here we use 3 wires DC Voltmeter. It has a LED screen by which we can measure the voltage of the output of the solar panel and battery voltage. It has 3 wires red wire connect to positive of power supply, Positive Yellow wire DC supply under test, Black wire is common for both dc Supply.

The specification of the voltmeter is:

1. Type – DC Digital
2. Voltage Range – 0-100 V DC
3. Working Current – Over 20mA

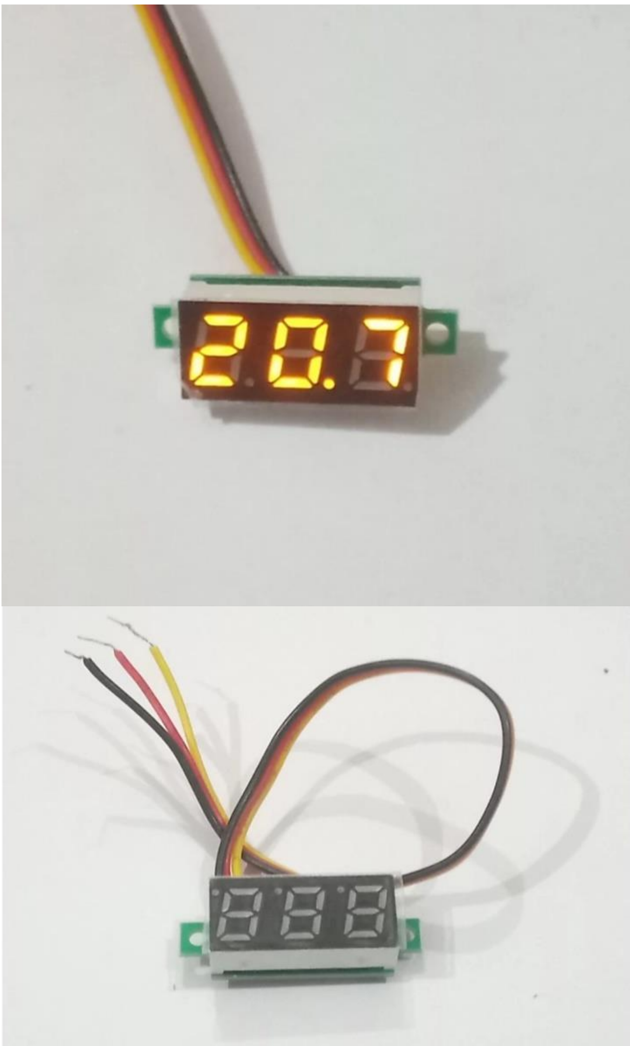

Fig. 9: DC VOLTMETER

CHAPTER 4: MATHEMATICAL MODEL

4.1 MATHEMATICAL MODEL OF BUCK CONVERTER WORKIG

The output voltage of a buck converter is given by the equation (2.1)

$V_0 = D\,V_{in}$ …………..(2.1)

Where D is the duty ratio of the MOSFET switch D is given by the equation (2.2)

$D = \frac{T_{on}}{T_{on}+T_{off}}$ …………..(2.2)

$0 \le D \le 1$ ………….(2.3)

Fig. 2 shows the working of a buck converter (with its switch in on position and off position respectively) pictorially. The red line shows the path of current.

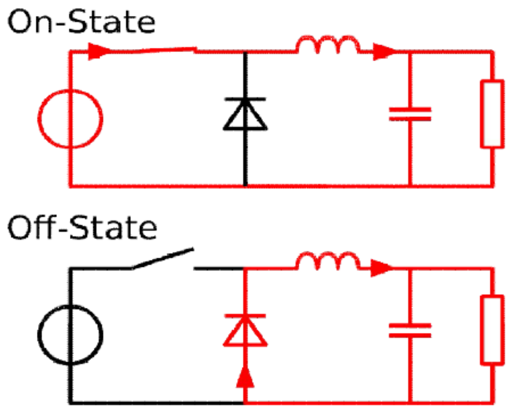

Fig. 10 schematic of working of buck converter

CHAPTER 5: SYSTEM IMPLIMENTATION

5.1 STEMATIC DIAGRAM

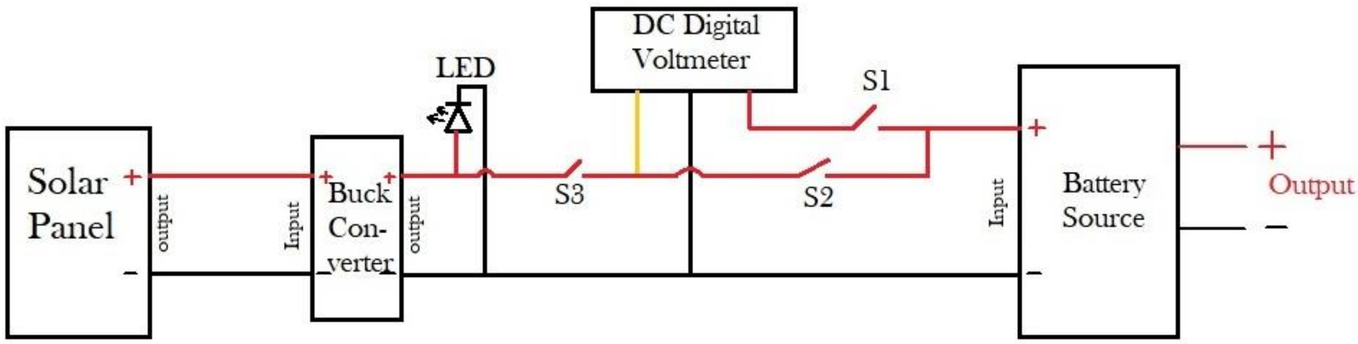

Fig.11 STEMATIC DIAGRAM OF THE SYSTEM

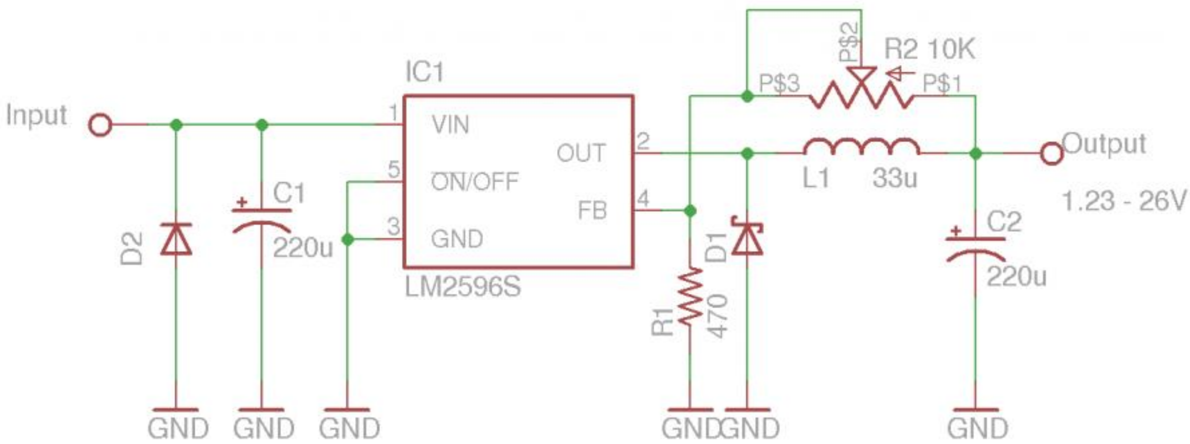

Fig.12 CIRCUIT DIAGRAM OF LM2596 DC-DC BUCK CONVERTER

5.2 OVSERVATION AND RESULT

Solar panel used is having 12V rating . A graph is plotted between voltage variation and time of day. We know that the solar energy received from the sun to earth varies whole day. From fig. 13 it is clear that maximum solar energy falls on earth at midday and hence the maximum voltage output is obtained at the same. The buck converter along with the battery storage system makes the input to the mobile phone a constant.

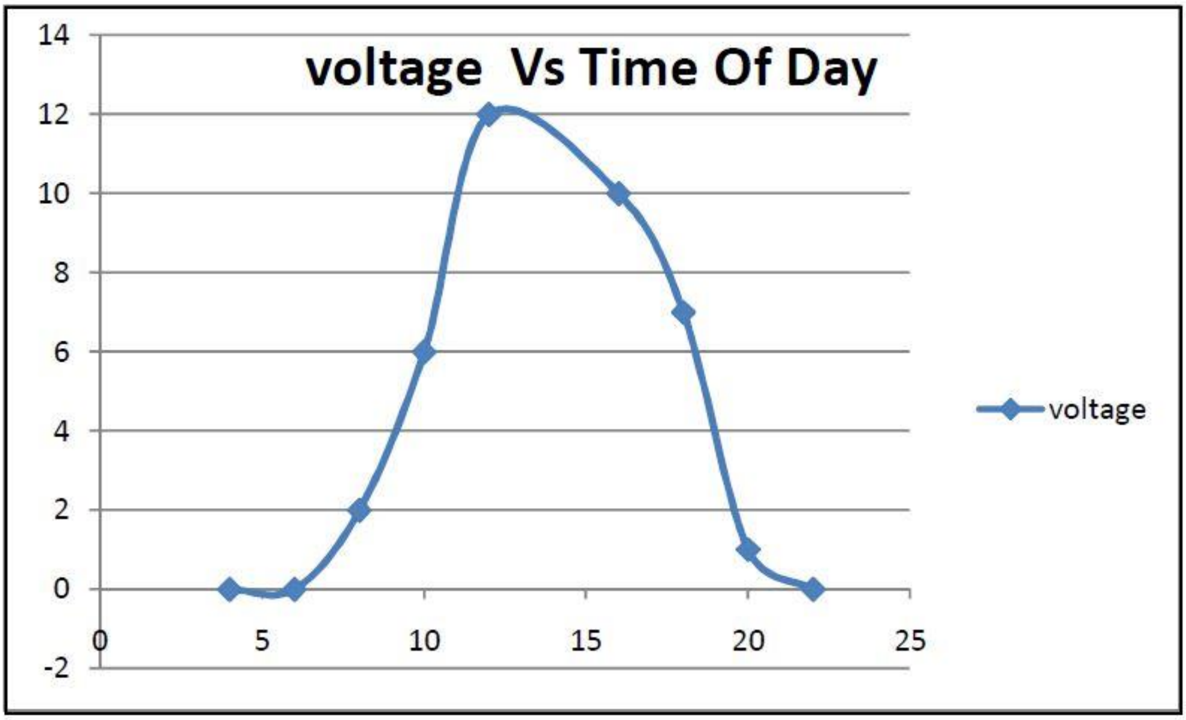

Fig.13 voltage vs time of day

The table 1 indicates the time taken to fully charge the battery using the solar panel at different times on a day in summer

Table 1: Time required charging a battery

Around 7am (morning)	2 hours
Around 10am (morning)	1 hours 15 minutes
Around 1pm (noon)	35 minutes
Around 5pm (evening)	1 hour 35 minutes

The table 2 shows the voltage across the solar panel at various times on a day. The following readings were taken on May 2019(day was cloudy).

Table 2: Voltage across solar panel

Time	Max. Voltage (in V)	Time	Max. Voltage (in V)
6am	2	1pm	14
7am	3.5	2pm	14
8am	6	3pm	10
9am	9	4pm	8.5
10am	10	5pm	6
11am	12	6pm	3
12pm	13	7pm	1.5

Fig. 14 Hardware implementation of the device

CHAPTER 6: CONCLUSION AND FUTURE WORK

6.1 CONCLUSION

Solar act as good power supplies in bright sunlight. The only problem is the unregulated voltage due to the variation in intensity of light. Voltage regulator is used to solve this problem by regulating the output voltage. The charge so obtained is stored in the battery and is given to the respective loads. The charge present in this battery is analysed and displayed on an LCD. Solar powered cell phone chargers can be a better alternative to electrical cell phone chargers. It will make the running cost of mobile phone reduced. For that purpose designed an eco-friendly solar powered charger (SPC) for mobile charging which utilizes an effective converter topology and microcontroller to ensure effective utilization of solar energy. A SOLAR POWER MOBILE CHARGER can accommodate almost any model cell phone. It can use the sun's energy to recharge a cell phone..

6.2 FUTURE SCOPE AND APPLICATION

Solar energy can only be harnessed when it is daytime and sunny. To overcome this, solar panels can be coupled with back-up battery which can store the excess power generated during the day and use it to provide energy to system in the absence of sunlight. The large size of the solar panel makes the device bulky and non-portable. The solar panel should be fabricated to cover the entire device, which can effectively reduce the size of the entire device.

For low-power portable electronics, like calculators or small fans, a photovoltaic array may be a reasonable energy source rather than a battery. Solar chargers can charge lead acid or Ni-Cd battery bank up to 48 V and hundreds of ampere-hours (up to 400 Ah) capacity. Small portable models designed to charge a range of different mobile phones, cell phones, iPods or other portable audio equipment. Public solar chargers permanently installed in public places, such as parks, squares and streets, which passers-by can use for free.

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