Solar Charger: A Green Way of Synthesizing & Using Energy

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Abstract: ***In this present paper, a speculative analysis has been effectuated to study the thermic attainment of a Solar charger. It is a domestic purpose solar charger & has executed its intended output in the climatic environment of Mumbai, India. It functions on the principle of 'Photovoltaic effect'. It harnesses the abundantly available solar energy with the aid of solar panels and transmutes it into electrical energy, a vital source to charge the much-used plethora of current technologies , examples of which include smartphones and laptops. In this paper, an experimental setup testing the charging process of mobiles along with the procured results have been reported. As per (Indian/American/European) standards, at (volts) and (hertz) , the tests were conducted, and the respective results were achieved. So, the author, contemplates to use solar charging owing to the reason, that in India, the source of the energy, is abundantly available approximately 8 to 11 hours per day annually and the charger can implement with a well expected output percentage.[1] This paper also includes performance analysis of components of solar charger. To evaluate the performance of solar charger, analytical and experimental results were procured, and a comparative study has been done.***

Keywords: Solar energy, Solar charger, Green energy, Photovoltaic technology

1. Introduction

It is no news to the masses that as of 2021, our planet Earth has arrived at a dire locus that our means of conventional energy sources are depleting in multiple folds in comparison to the amounts which our antecedent decades had. At present, with the advances attained in scientific and ecological domains, society in great numbers is much concerned about the vice-effects of conventional sources of energy & give uttermost emphasis to the rapidly squandering of conventional entities. Acclimatizing with renewable energy or what can be termed as "Eco-friendly" energy is in vogue at the time with the vision to reduce reliance on the limited repositories of fossil fuels and to allay negative impacts on the environment.

Among the array of renewable energies, fructification of electricity from sunlight over the last decade has been thriving in augmentative proportions globally due to the affirmative and optimistic impact it has projected in salvaging the ecosystem. Preservation of the environment isn't wholly a local issue, nonetheless a worldwide concern.[2]

Acclaimed as a greenhouse gas and shown to absorbing and emitting thermal radiations thereby giving rise to the phenomenon of 'greenhouse effect, Carbon Dioxide (CO2) along with a range of other greenhouse gases including the likes of methane and methane(CH4) and nitrous oxide (N2O) are elevating overall global temperatures due to the industrialization and a ton of other human activities vandalizing and encroaching upon the bountiful ecosystems present. A renewable source such as solar energy which will be our main focus, will be of great aid as it is ever- available and requires no disruption of nature. The law of conservation of energy plays a quintessential role as the consumption of conventional sources of energy drastically inflicts damage on our environment. Due to the promising developments witnessed in the domain of solar technologies supported by the geographical and climatic aspect which facilitates availability of the sun in India for nearly 8 to 11 hours a day, solar energy would serve as a great source of eco-friendly energy complementing the current methods of making fuel and energy available & in the future, a prime source or entity of harnessing power. [1]

Solar charger consists of technology which converts solar rays into electricity, stores and supplies whenever at need. This is wholly possible due to solar modules or solar arrays.

A solar module is a single photovoltaic panel which is an assimilation of grouped solar cells (Photovoltaic or PV cells) used to harness power. An array on the other hand, is a product of several combined solar modules/panels. Presently, silicon (Si) is the most preferred semiconductor used to create solar cells.

These cells are systematized together edge-to-edge in photovoltaic power stations, to obtain sunlight & are also seen on roofs of houses and other buildings at times. As the cells are made from semiconductor materials, it loosens electrons from their atoms when the sun's rays come in contact with the cells. This facilitates the electrons to flow through the cell and generate electricity. When light strikes the cell a supposed quantity of energy is absorbed within the semiconductor material, knocking electrons that form the core aspect of electricity through photovoltaic effect.

2. Research Objective:

The Sun has the enormous untapped potential to supply our demanding energy requisites. The hindrance to larger use of the solar energy is its sky-high cost relative to the price of fossil fuels, although the incongruity will diminish with the rising prices of fossil fuels and the rising costs of mitigating their impact on the environment and climate. The cost of solar energy is directly proportional to the low conversion efficiency, the modest energy density of solar radiation, and the costly materials currently required. The development of materials and methods to improve solar energy conversion is primarily a scientific demanding, Breakthroughs in primordial understanding ought to enable visible progress. There is plenty of space for improvement, as photovoltaic conversion efficiencies for inexpensive organic and dye-sensitized solar cells are approximately about 10% or less at present, the conversion efficiency of photosynthesis is less than 1%, and at most, solar thermal efficiency achieved is 30%. The theoretical limits indicate that we can do much better.[3]

The experimental composition mainly makes advantageous use of the sunlight as a resource available in the geographical positioning of our region, to take a small step on the road towards adapting cleaner energy harnessing and usage practices. It has a better leeway for providing a constant source of energy procurement in rural areas thereby energizing the bucolic regions and leading a step towards development. The composition assesses the functioning of the solar charger. The performance and difference between the output delivery of devices charged by traditional and solar based chargers are also reported. While working and assessing the project, we found that major disadvantage with solar energy conversion system is low overall efficiency of the system. In the current scenario, solar electric power generation systems are comprising of stationary solar panels whose efficiency of generation is very low. [4]

To improve efficiency of the system, performance analysis of various components of solar charger is to be done.

To evaluate performance of solar charger, analytical and experimental results were procured, and a study based on their correlation has been done.

3. Impact:

In our day-to-day lives, as per the reports of the Telecom and Regulatory Authority of India (TRAI, 2008-09), cell phone subscriptions saw an unprecedented rise of 50% from 261 million to 506 million. As of 2017, the Indian subcontinent comprised estimated 700 million active phone users which elevated to 749 million in the preceding year. Apart from these, the pandemic induced online or virtual mode of life increased energy consumption in totality through the medium of charging electronic devices.[5] As quipped "Necessity is the mother of invention", such times call for alternative and safe measures. This, consolidated by the unavailability of a stable, continuous source of electricity in the majority of the rural and bucolic regions of India, gives substantial backing to solar energy as an option which may come to fruition if worked efficiently upon. Based on early discoveries and inventions, a major game changer in this technology would be solar cells or more popularly known as Photovoltaic cells. In daily life applications, they are found in calculators. PV cells as the name suggest (photo meaning "light" and voltaic meaning "electricity") is the convertor which performs the conversion of the naturally and abundantly available sunlight into electricity.[6] Thus, if solar chargers are introduced , it could be a secure, serviceable, non-pollutant mode of electricity procurement in the future.

4. Working Principle:

The solar charger is a backup system capable of operating on both solar power as well as a backup Lead acid battery. The battery is capable of providing an ostensible current of 8 amperes/hour at 12.6 volts. The completely charged battery voltage is 14.4 volts. The battery is energized with the medium of a common input which upholds a range of voltages from 12 volts to 35 volts and this is made possible by using an Auto Buck-Boost converter inline to give a substantially regulated 15 volts output to charge the Lead acid battery. The Buck-Boost converter is capable of providing a maximum output current of 3 A and can regulate input voltages from DC 3.5-28 volts to output voltages DC 3.5-28 volts which if tuned to 15 volts at 3 amperes max would completely charge the battery ideally in 3 hours. DC sockets are used to approbate the input which can either be a charger adequate at supplying a voltage between the range or with the photovoltaic panel. The system comprises an inline solar charge controller to provide a steady DC output and protection from overcharging and over discharging. The solar panel in use is a 12 volts 15 watts Polycrystalline panel which would administer a maximum short circuit current of 0.92 amperes with direct uninterrupted incident radiation. With efficient use of this panel, the system can be completely charged in approximately 9 hours.

The solar charge controller monitors all the power going in and out of the battery. In the presence of adequate sunlight , the battery is charged. When the battery is completely charged and reaches its maximum voltage of 14V DC , the charge controller bypasses the battery and transmits the power from the panel directly to the load with some inline modulation to prevent instability in power output. However , when the weather changes and turns cloudy thereby, covering the panel and hampering the intensity of sunlight , the charge controller quickly switches to backup power and the battery power starts being consummated. The controller also provides an array of safety measures for the battery such as over voltage protection and under voltage protection, to name a few so as to keep the battery safe. The power from the controller is then fed into various other modules with inline switches to avoid unnecessary consumption of power. For charging a cellphone , two QC 3.0 buck converters are present which convert the output 13V of the controller to 5V by default. However, when the quick charge protocol is triggered , it can shift between 5V DC to 12V DC depending upon the requirement of the mobile device. Two of such modules are present to allow two devices to be charged at a rapid rate simultaneously. The boost converter is used for charging devices that require higher power such as laptops. When the switch for the boost converter is turned on , the boost converter uses the power from the controller and steps it up to the voltage required by the user above 12 V . The voltage and current can be precisely set using the onboard control pots. Various connectors are also present to make the system modular and easy to move. With the experimental setup, at a time it is possible to charge 3 devices simultaneously.

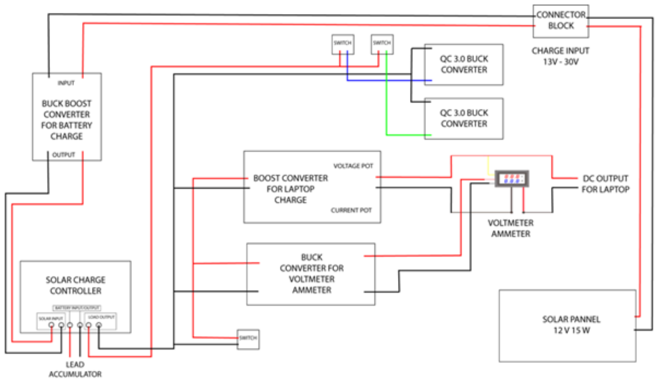

Figure 1 : Block Representation of Solar Charger

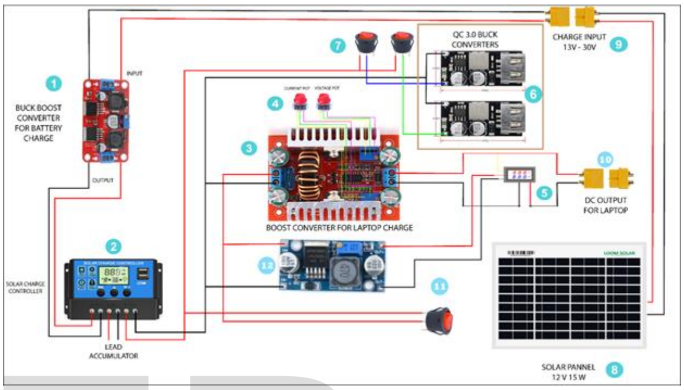

Figure 2 : Pictorial Representation of Solar Charger

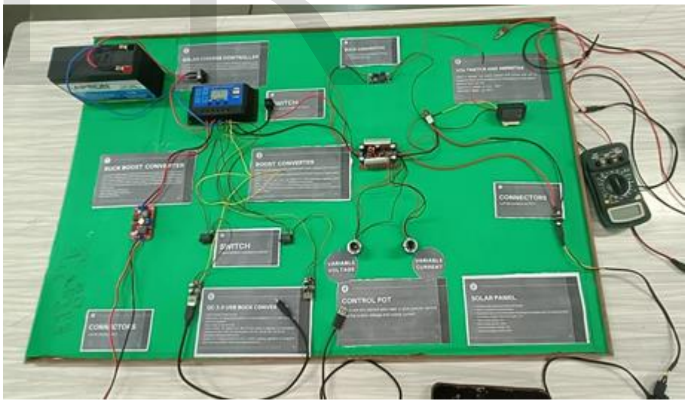

Figure 3 : Experimental setup of Solar Charger

5. Apparatus for Experimental Setup:

These components are the requisites for the experimental setup of the solar charger :

5.1. Xcluma Digital Voltmeter/Ammeter:

Table 1: Comparative analysis of digital voltmeter/ammeter

	TYPES	FEATURE	POWER OUTPUT/RATING	PRICE RANGE
Voltmeter Ammeter	**xcluma Digital Voltmeter Ammeter Dc 0-100V 10A**	**Can measure both Voltage & Current**	**1. Operates between: 4.5V to 30V DC 2. Voltage sensing range: 0V to 100V 3. Current rating: 10A**	**Rs 320 - Rs 485**
	Limitless Products DC Dual Display Meter Volt Amp Meter		1. Operates between: 4V to 30V DC 2. Voltage sensing range: 0V to 100V 3. Current rating: 100A	Rs 800 - Rs 2500
	Electronicspices 0.28inch 0-100V Three Wire DC Voltmeter	Can measure only voltage	1. Operates between: 4.5V to 100V DC 2. Voltage sensing range: 0V to 100V 3. Current rating: 10A	Rs 120 - Rs 300

There are an array of voltmeters and ammeters available in the market with the prime variants being digital and analogue. The analogue meters are readily available and are economical as compared to the digital meters. However, there is a deviation of accuracy between these types with the digital meters being more accurate but slightly more expensive than the analogue ones. The analogue meters do not have various kinds of protections which are needed for error free , accurate measurement. The digital meters on the other hand directly display the measurement data with the help of a LED display whereas the analogue meters use a moving suspended needle to display the measurement reading which increases the chances of human errors. Also, the resolution of the digital meters is much better when compared to the analogue ones.

The meters used in this model are all of the digital types. It has a red display to show the voltage and a blue display to show amperage. The meter itself has an operating voltage range from 4.5V to 30V and has a voltage measurement range from 0V to 100V alongside also has a 10A max rating.

Figure 4: Digital Voltmeter/ Ammeter

5.2. Buck Converter:

'Buck conversion' refers to the stepping down of input voltage to give a lower output by increasing the current. It is generally used for DC applications.

A Buck converter consists of an inductor which is switched on and off using an N channel MOSFET which acts as a switch and is controlled by a PWM signal. When the input is switched on and off at 50% duty cycle , the voltage at the output is reduced by 50% as compared to the input. To smooth the high voltage peaks from the MOSFET , an inductor is added to smooth it. An inductor does not allow any change in the value of current. When a current flows through the inductor , energy is stored in the form of a magnetic field around the inductor which collapses when the source is disconnected from it. When the MOSFET allows the flow of current through the inductor, the inductor resists this flow and drops the voltage. A low voltage drop Schottky diode before the inductor prevents the components from being damaged by the reverse flow of electrons and the capacitor helps maintain a constant output. The output of the Buck converter depends on the duty cycle of the PWM signal. As the duty cycle is increased, the voltage increases and as the duty cycle decreases , the voltage also decreases.

Various kinds of buck converters are used in this model. Names and function of which are as follows:

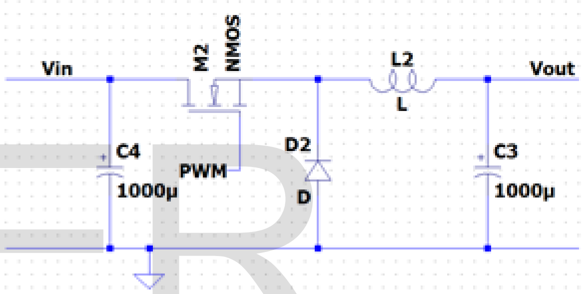

Figure 5: Schematic Representation of Buck converter

Table 2 (a) : Comparative analysis of Buck converter

	TYPES	FEATURE	POWER OUTPUT/RATING	PRICE RANGE
Buck Converter	**LM2596 HV Buck converter**	**1. Conversion efficiency is 92% 2. Variable voltage only**	**1. I/P Voltage: 3V to 40V DC 2. O/P Voltage : 1.5Vto 35V DC 3. Output Current 2A**	**Rs 50 - Rs 160**
	XL4015 Buck converter	1. Conversion efficiency is 96% 2.Variable voltage only	1. I/P Voltage : 4V to 38V DC 2. O/P Voltage: 1.25V to 36V DC 3. Output Current 3A	Rs 90 - Rs 200

Table 2 (b) : Comparative analysis of Buck converter

	TYPES	FEATURE	POWER OUTPUT/RATING	PRICE RANGE
Mobile Charger	**CKCY U1A QC 3.0 buck converter**	**1. Conversion efficiency is 91% to 97% 2. Multiple O/P Voltages 3. Various fast charge protocols supported**	**1. I/P Voltage :6V to 32V DC 2. O/P Voltage : 5V default 3. QC 3.0 output : 5V, 9V, 12V**	**Rs 160 - Rs 350**
	Generic Dc-Dc Buck Module USB Step Down Power Supply Charger	Conversion efficiency is 97.5%	1. I/P Voltage 9V to 24V DC 2. O/P Voltage 5V 3. Output Current 3A	Rs 120 - Rs 300

5.2.1. LM2596 HV Buck Converter:

The Buck converter will maintain a constant lower output voltage which can be tuned using the onboard pots irrespective of the input voltage. Since this is a Buck converter , it will only buck a voltage higher than the input voltage rating of the converter. The buck converter will help maintain a constant lower output in case of a rise on the input side. Various types of buck converters are available in the market which all serve their own vivid purposes. The LM2596 HV is a low power buck converter which can accept an input voltage range from 4.5V to 40V and give a constant output voltage within the range 3V to 35V DC. This buck converter can output a maximum power of 15W which is sufficient for the application desired. XL4015 which can deliver 75W of power.

Figure 6: LM2596 HV Buck Converter

5.2.2. CKCY U1A QC 2.0 - QC 3.0 Buck Converter:

The CKCY U1A is a QC 2.0 - QC 3.0 buck converter that is generally used as a power supply for charging normal USB gadgets as well as gadgets which support the QC (Quick Charge) protocol. The module supports an input voltage range of 6v to 32V DC and can give different levels of outputs. The default output of the converter is 5V & 3.4A DC .When the QC 3.0 protocol is active the module can give an output of 5V with 200mV of increments depending on the requirement of the gadget. The module has various kinds of protections such as Input Overvoltage protection , Overcurrent protection , Undervoltage protection and Short circuit protection.

Figure 7: CKCY U1A QC 2.0 - QC 3.0 Buck Converter

5.3. 400W Boost Convertor:

Table 3: Comparative analysis of Boost converter

	TYPES	FEATURE	POWER OUTPUT/RATING	PRICE RANGE
Boost Converter	**REES52 DC-DC Step-up Boost Converter**	**1. Adjustable O/P Voltage 2. Adjustable Output Current**	**1. I/P Voltage 8.5V to 50V 2. O/P Voltage: 10V to 60V 3. Max Output current 15A**	**Rs 790 - Rs 1200**
	XL6009 DC-DC Adjustable Step-up Boost Power Converter	Adjustable O/P Voltage	3. I/P Voltage 5V to 32V 4. O/P Voltage: 6V to 35V 5. Max Output current 3A	Rs 160 - Rs 300

‘Boost conversion’ refers to the stepping up of an input voltage to give a higher output by decreasing the current. It is generally used for DC applications.

A Boost converter basically consists of an inductor which is switched on and off using an N channel MOSFET which acts as a switch and is controlled by a PWM signal. It is the property of the inductor that it does not allow any changes in current. When current flows through the inductor , energy is stored in the form of a magnetic field around the inductor. When the circuit is opened , no current flows through the inductor and the magnetic field around the inductor collapses resulting in the flow of a high current towards the load. However, this much current is not required by the load and cannot be changed quickly. The inductor, hence, increases the value of voltage in a way that the overall combined voltage of the battery and the inductor is enough to let the current produced flow through the load. A diode inline ensures that the current hence produced does not flow back into the inductor and the capacitor helps maintain a constant output. The output of the Boost converter depends on the duty cycle of the PWM signal. As the duty cycle is increased, the voltage increases and as the duty cycle decreases , the voltage also decreases.

The boost converter will maintain a constant higher output voltage which can be tuned using the onboard pots irrespective of the input voltage. Since this is a Boost converter , it will only boost a voltage lower than the highest output voltage rating of the converter. The boost converter will help maintain a constant higher output in case of a drop on the input side.

Boost converters are available in a multitudinous range of power ratings starting from 70W and going all the way till 1600W and beyond. However, for this application a 400W boost converter is sufficient as higher power boost converters draw higher power on the input even when not needed. Hence, to maintain a larger backup period , a 400W boost converter was the most considerable choice.

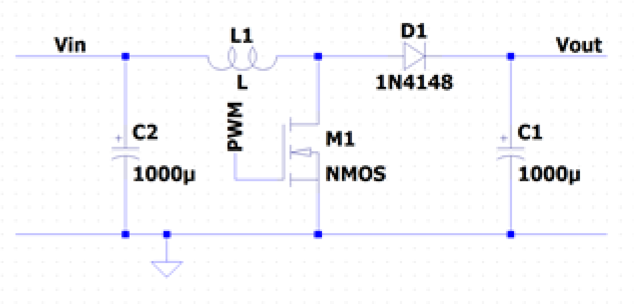

Figure 8 (a) : Schematic Representation of Boost Converter

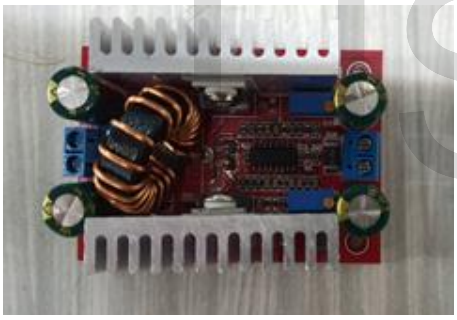

Figure 8 (b) : 400W Boost Converter

5.4. LM2596 & XL6009 Auto Buck-Boost Converter:

Table 4: Comparative analysis of Buck-Boost converter

	TYPES	FEATURE	POWER OUTPUT/RATING	PRICE RANGE
Buck Boost Converter	**LM2596 & XL6009 DC-DC Adjustable Step-Up and step-down Power Supply Module**	**Control Pot Variable output**	**1. I/P Voltage: 3.5V to 28V DC 2. O/P Voltage: 1.25V to 26V DC 3. Output Current 3A**	**Rs 360 - Rs 500**
	Converter, Auto Buck-Boost Board Numerical Control Step Up Down Module	Numerical control variable output	1. I/P Voltage: 10V to 40V DC 2. O/P Voltage range 0V to 38V DC 3. Output Current 6A	Rs 1200 - RS 1900

A buck boost module is a combination of both the buck as well as the boost converters with the input voltage first passing through the boost converter and being stepped up to a particular value and then being fed into the buck conversion side of the converter which will then lower the voltage to the desired value. Such a configuration of first boost then buck is used to maintain a better efficiency and also support a wider output range of voltage ranging from 1.25V to 26V DC.

The module will automatically shift between buck and boost modes depending on the set value to maintain a constant DC output regardless of the input being either higher or lower from the set value.

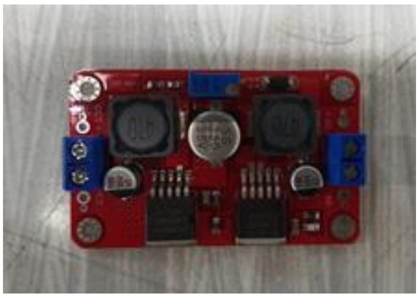

Figure 9 : LM2596 & XL6009 Auto Buck-Boost Converter

5.5. Solar Charge Controller:

Table 5: Comparative analysis of Solar charge controller

	TYPES	FEATURE	POWER OUTPUT/RATING	PRICE RANGE
Solar Charge Controller	**HASTHIP® LCD Display 10A amp Solar USB Charge Controller Regulator 12V/24V Auto Switch**	**1. Auto on off timer 2. LCD Display 3. User selectable functions 4. Efficiency 98%**	**1. Max panel power input 480W 2. O/P Voltage 12V DC constant 3. Output Current 10A**	**Rs 600 - Rs 1200**
	Luminous 6 Amp Solar Charge Controller	1. Efficiency 98% 1. Preset Functions	1. Max panel power input 400W 2. O/P Voltage 12V DC constant 3. Output Current 10A	Rs 350 - Rs 900

The solar charge controller controls the amount of power entering and leaving the battery. The controller has 3 pairs of terminals.

A. From left to right , the first pair is for the input power from the solar panel.

B. The second pair of terminals is for the battery .

C. The third one is for the load.

The controller on a sunny day, when the panel receives enough radiation and delivers max power will deliver the power to the battery in a controlled manner to charge the battery. Once the battery is completely charged, the controller will bypass the battery and feed the power from the panel directly to the load keeping the battery as a backup. When the power from the panel reduces , the controller will quickly and automatically take power from the battery and the load will continue to receive power. The controller provides various protections for safely charging and discharging the battery. Overcharge cutoff limit and over discharge cutoff limit can be set using the onboard lcd and the buttons for navigation.

Figure 10 : Solar Charge Controller

5.6. Solar Panel:

Table 6: Comparative analysis of Solar panel

	TYPES	FEATURE	POWER OUTPUT/RATING	PRICE RANGE
Solar Panel	**Solar Panel 15W JEE-LITE**	**Poly Crystalline Technology**	**1. Open circuit voltage 21V 2. Short circuit current 0.92A 3. Max power output 16W**	**Rs 890 - Rs 2000**
	Loom Solar Panel 10 watt	Poly Crystalline Technology	1. Open circuit voltage 22.5V 2. Short circuit current 0.52A 3. Max power output 10W	Rs 900 - Rs 1400
	Loom Mono Crystalline Solar Panel	Mono Crystalline Technology	1. Open circuit voltage 22.5V 2. Short circuit current 2.51A 3. Max power output 50W	Rs 2600 - Rs 4500

Two types of panels are available which are:

A. Mono crystalline

B. Poly crystalline.

The mono crystalline panels are able to provide higher power and have greater efficiency but are expensive. The polycrystalline panels however can deliver lesser power but are cost effective when it comes to small scale applications. The solar panel used is a 16W polycrystalline panel whose dimensions are 32 cm × 31.5 cm and has a surface area of 0.10075 square meter. The panel can deliver enough power to charge the lead acid battery used in 6 hours.

The panel can supply an open circuit voltage of 22V. Under load conditions , the panel can supply a short circuit current of 0.92 A and a maximum voltage of 18V.

Figure 11 : Solar Panel

5.7. Lead Acid Battery:

Table 7: Comparative analysis of Battery

	TYPES	FEATURE	POWER OUTPUT/RATING	PRICE RANGE
Battery	**Lead Acid**	**1. Charge density is 30 to 50 Wh/kg 2. Can provide Instantaneous high current**	**1. Normal voltage: 12V 2. Fully charged voltage 13.6 V 3. Output current 8Ah**	**Rs 800 - Rs 1500**
	Nicd cells	1. slow charging 2. Shows memory effect 3. cycle life of 50 to 100	10 Cells for a total of 12V Energy density is 45 to 80(Wh/Kg)	Rs 3000 - Rs 3500
	Lithium-Ion	1. Needs active balancing. 2.Needs current regulated show charging	3 Cells for a total of 12V Output current typically 2.6 Ah for 3S battery pack .High Charge density (90 to 120 Wh/kg)	Rs 1200 - Rs 3000

The battery performs the function of storing the charge which can be used as a backup in the absence of sunlight and when the panel is unable to supply enough power. Various options available are:

A. NiCad

B. Lithium Ion

C. Lead acid.

The NiCad cannot be used as the charge density of the NiCad cells is insufficient when it comes to space. Also, the NiCad cells show properties such as 'Memory effect' wherein if the NiCad cells are not charged and discharged completely then the battery tends to retain the smaller capacity.

Lithium-Ion cells have a greater charge density and do not show properties such as memory effect. They do need to be charged and discharged safely, requiring a BMS (Battery Management System) to safely charge the individual cells and to maintain a perfect balance between the different cells of the battery pack. The Lithium-ion cells however are expensive and also require maintenance.

This makes Lead Acid batteries as the most practical and preferred selection. Lead acid batteries are the most common batteries used in most appliances and even vehicles as the maintenance required is very low and are quite cost effective when compared to other types. Also, since this model is mainly stationary , space would not be a concerning factor. Lead acid batteries also have the ability to deliver large amounts of current for a short duration of time. The battery used is a 12 V 8Ah battery which can provide a backup for 7 hours in ideal conditions.

Figure 12 : Lead Acid Battery

5.8. Control Pots:

The control pots are used as a replacement for the onboard control pots on the boost converter as the turn life of the control pots on the boost converter is only 200 turns. The ones used as a replacement have a turn life of 1,000,000 shaft revolutions.

Two control pots are used with values 10K ohm and 5K ohm to provide greater resolution while selecting the variable voltage and current.

5.9. Switches:

The switches are used to open and close the circuits for the USB 3.0 Buck converters, the lead acid battery, and the boost converter to save power when not needed.

Figure 13 : Switches

5.10. Plugs & Sockets:

The plugs and sockets are used to make the model more modular and are used for the solar panel input as well as the laptop charge output so as to allow the user to quickly disconnect and connect the required gadgets.

Figure 14 : Plugs & Sockets

6. Mathematical modelling of Solar charger:

To obtain analytical results, mathematical modelling of solar charger is done as shown below:-

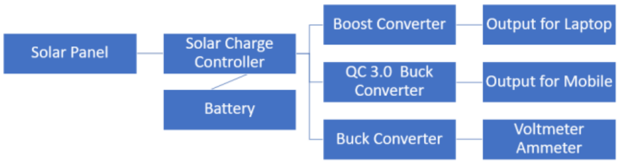

Figure 15 : Block representation of components

6.1. Equation:

Overall Efficiency= output/input

$$\eta_{Overall} = \frac{Output}{Input}$$

$$Output = \eta * Input$$

$$Output = \eta_{panel} * \eta_{buck-boost.converter.input} * \eta_{charge.controller} * \eta_{battery} * \eta_{boostconverter\ or\ QC\ 3.0\ Buck\ converter\ or\ buck\ converter} * Input$$

Sample Calculation:

= 59.241*0.11*0.95*0.94*0.5*0.97

= 2.822333 W

6. Observation:

Table 7: Input for Experimental Results

Time	Input		
	Intensity (W/m2)	Area (m2)	Power (W)
1:15 IST	799		80.499
1:30 IST	809		81.506
1:45 IST	803		80.902
14:00 IST	795		80.096
14:15 IST	784		78.988
14:30 IST	725	0.10075	73.043
14:45 IST	680		68.51
15:00 IST	655		65.991
15:15 IST	636		64.077
15:30 IST	588		59.241
15:45:IST	533		53.699

Table 8: Experimental Results

Time (IST)	Output				Efficiency (Experimental) (%)
	Voltage (V)	Current (I)	Power Practical (W)	Power Theoretical (W)	
1:15	3.17	1	3.17	3.8350	3.9379
1:30	3.078	0.97	2.98	3.8830	3.6631
1:45	3.088	0.86	2.65	3.8542	3.2825
14:00	3.067	0.99	3.03	3.8158	3.7908
14:15	3.087	0.97	2.99	3.7631	3.7909
14:30	3.095	0.94	2.90	3.4798	3.9829
14:45	3.1	0.95	2.94	3.2639	4.2986
15:00	3.103	0.96	2.97	3.1439	4.5140
15:15	3.12	0.95	2.96	3.0527	4.6256
15:30	3.08	0.9	2.77	2.8223	4.6791
15:45:	3.122	0.82	2.56	2.5583	4.7673

Table No 9: Analytical Results

Time (IST)	Input			Efficiency (Overall)	Power (Analytical) (W)
	Intensity (W/m2)	Area (m2)	Power (W)		
1:15	799	0.10075	80.49	0.04764	3.8351
1:30	809		81.50		3.8831
1:45	803		80.90		3.8543
14:00	795		80.09		3.8159
14:15	784		78.98		3.7631
14:30	725		73.04		3.4799
14:45	680		68.51		3.2639
15:00	655		65.99		3.1439
15:15	636		64.07		3.0527
15:30	588		59.24		2.8223
15:45	533		53.69		2.5583

Table No 10: Overall Error Calculation

Experimental	Analytical	Overall
3.835097133	0.66509713	3.17
3.883072174	0.89741217	2.98566
3.854296678	1.19861668	2.65568
3.815897589	0.77956759	3.03633
3.763110751	0.76872075	2.99439
3.479881737	0.57058174	2.9093
3.263922591	0.31892259	2.945
3.143913526	0.16503353	2.97888
3.052727599	0.0887276	2.964
2.822333064	0.05033306	2.772
2.558303593	-0.0017364	2.56004

7. Results & Deliberations:

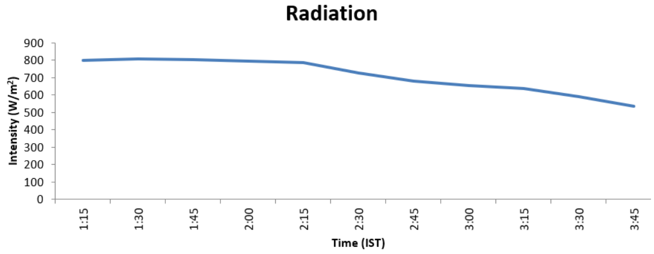

Figure 16: Testing Solar Intensity with respect to time

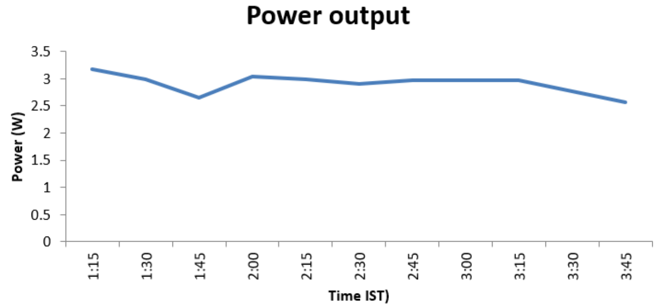

Figure 17: Experimental power output

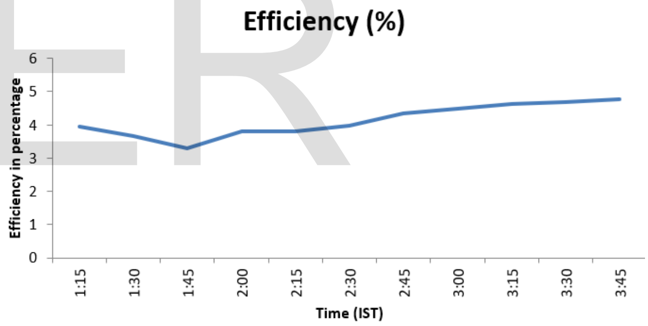

Figure 18: Efficiency with respect to time

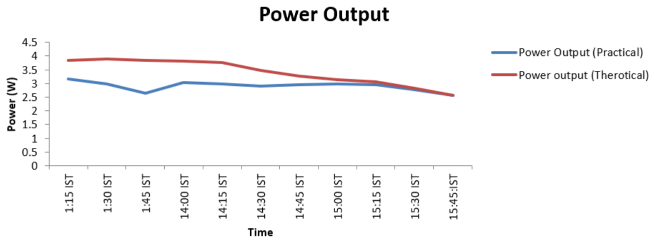

Figure 19: Power output (Theoretical & Experimental)

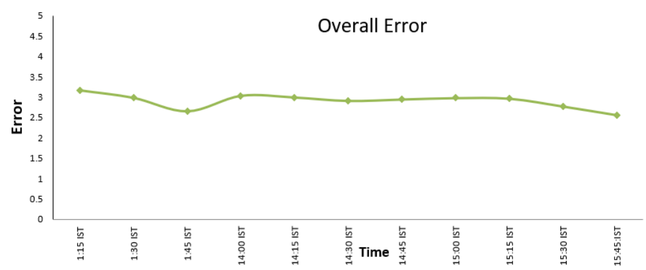

Figure 20: Error difference

8. Conclusion:

In this paper, study of a conveyable solar charger has been done. An explanation has been provided about the functioning and composition of the solar charger. There are a plethora of aspects pertaining to solar energy and solar charger requiring development and areas needing adequate amount of attention in the unforeseeable future. As the name suggests, solar chargers would require sunlight as a basic requisite and thus, would be non-functioning at night but as suggested, Lead acid battery thus, becomes a viable backup alternative.

9. Future Scope:

The domain of solar energy is that of an inchoate science. Its study received a lift during the 1970s, propelled by the oil crunch that brought into light the comprehensive importance of energy to many vivid sectors of our life. Contradictory to this is the development of fossil-fuel science which stretches to over two and a half centenaries, aroused by the Industrial Revolution and the insurance of abundant fossil fuels. Solar energy science is faced with an equivalently prosperous future, with nanoscience facilitating the empiricism of the guiding principles of photonic energy conversion and their implementation in the enrichment of cost-effective new technologies.[3]

In the times to come, solar charger can be used as a primary green energy synthesizing device to power laptops, smartphones and with further developments for other electronic devices too. Work can be done to solve challenges concerning the productivity, accessibility, and certainty of the device to make it more refined and a strong contender to give the masses a push towards adopting green sources of energy devices for their daily activities.

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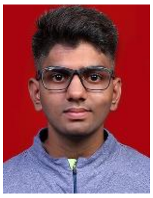

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