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SIMULATION AND DESIGN OF BATTERY CHARGER AND BALANCE OF SYSTEM FOR SOLAR INVERTER

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ABSTRACT: Solar Power plays a important role in the energy sector today. There is a strong demand in the current and future time of reliable and safe source of electrical energy. Solar energy has been increasingly used in order to develop clean and sustainable energy sources. It can be utilized for many applications. Because of downward tendency in the prices of PV modules and increment in the prices of conventional fuels, use of PV modules and solar energy is increasing day by day. The main objective of this project work is to design A solar charge controller .Which is a device needed for monitoring and controlling the charging of battery bank connected to the PV modules. Main function of Solar Charge Controller is to limit the rate at which electric current is added to or drawn from the batteries. It prevents overcharging and protects battery from voltage fluctuation, which can reduce battery performance or lifespan and may pose a safety risk.

I. INTODUCTION

RENEWABEL ENERGY

Because of the limited reserve of fossil fuel and the cost, from the beginning of the industrial age, renewable energy resources have been explored. Although solar energy is by far the largest resource of renewable energy, other renewable energy resources, including hydropower, wind power, and shallow and deep geothermal energy, has been extensively utilized. Except for deep geothermal energy, all of them are derived from solar energy. The world demand for electricity is growing rapidly. It surpasses demands for any other energy end-use. The IEA's World Energy Outlook foresees that with an annual average growth rate of 2.8%, electricity will almost double between 1997 and 2020. Primary world energy supply is expected to increase by 30% in 2010 relative to 1997, and by nearly 60% by 2020. Annual electricity demand grows unevenly in developed (projected to be 1.6% (OECD countries) and developing countries (projected growth rate 4.6%). It should be noted here that the developing world is in urgent need of energy, since more than 1.6 billion people until recently have lived without the benefit of modern energy services. With such increasing demands, the present growth pattern is strongly influenced by the domination of fossil fuels. In developing countries where electricity supplies are inadequate, renewable energy can offer an alternative to expensive extensions of the grid to sparsely populated or rural areas, or a contribution to the grid-based energy mix to meet rapidly expanding electricity demand in urban areas. Other associated benefits include economic and social development, healthier environment, income generation for local communities, capacity building, and development of local employment and expertise.

World Total Primary Energy Supply

Renewable is a term used for forms of energy which are not exhausted by use over time. It means that the renewable resources can be regenerated or renewed in a relatively short time. The following leading renewable resources: biomass, wind, geothermal, solar and hydro. Industrial heat recovery power (IHRP) is a fairly novel approach to improving industrial energy efficiency by means of power generation, and in the US it is now included in the Renewable Energy Portfolio Standards. The sources of renewable energy can be divided, according to their origin, into natural renewable resources (wind, geothermal, solar, hydro, etc.) and renewable resources resulting from human activity (biomass, including landfill gas and industrial heat recovery power).

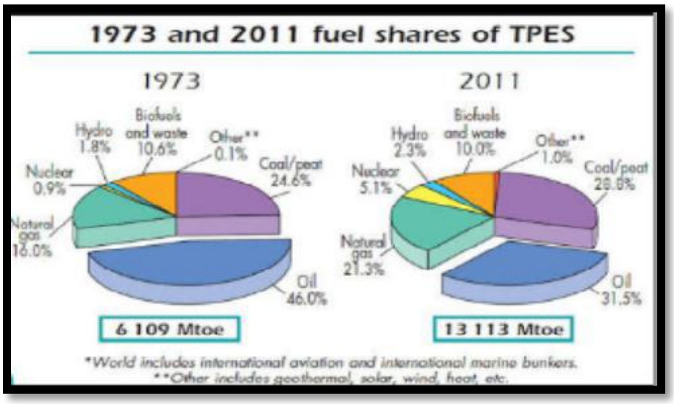

Fig: Fuel Shares of TPES in 1973 and 2011

SOURCES OF RENEWABLE ENERGY

- WIND POWER
- SOLAR POWER
- SMALL HYDRO POWER
- BIOMASS
- GEOTHERMAL

SOLAR POWER

Solar-powered systems typically must operate from a very wide input-voltage range due to the large variations in a solar panel's output voltage. This wide operating range limits the system's ability to consume maximum power from the solar cell under all light conditions. The ideal solar charging application operates the solar cell at its maximum power point (MPP) while simultaneously limiting the input-voltage range of the system.

This goal is achieved by integrating a narrow-voltage DC/DC (NVDC) battery-charging architecture with a solar-charger design. The narrow voltage range for the system power bus provides higher system efficiency, minimizing battery charging times and extending battery run times .This article shows the NVDC charging architecture in a solar charging application and introduces a circuit that provides acceptable charger operation under several operating conditions, such as battery over temperature, a discharged battery, a fully charged battery, and a system-current overload. Solar Photovoltaic systems use solar panels to convert sunlight directly into electricity. System incorporates photovoltaic panels, inverter system, and control circuit depending on the application. Materials used for making of solar panels are,

- Wafer based Si Solar Cell technologies- Mono-crystalline and Multi-crystalline. (Comparatively High efficiency High cost) .
- Thin film Technologies- Amorphous Si, Cd, Te, CIGS and many more. (Comparatively Low efficiency Low cost) .
- Future Technology- Thin film Crystalline Si. (High efficiency Low cost) .

More than 90% of the solar cells produced at present are of crystalline silicon. Crystalline Si modules have higher efficiency compared to thin film technology. Commercial modules have efficiencies between 12% to 18% and laboratory cells have record efficiency of 24.7%. In wafer based technology, quasi-square-shaped mono-crystalline wafers are more expensive and difficult to assemble; also mono-crystalline wafer assembly causes considerable material loss. But on the other hand square shaped multi-crystalline Si wafers are easy to or convenient to assemble. Multi-crystalline wafers are cheaper, cells fabricated in the multi-crystalline Si are capable of producing cells of about 90% of the performance of a mono-crystalline cells. Wafer based technology materials are indirect band gap materials and their absorption coefficient is lesser than thin film technology materials. Hence thicker layer of material is required. On the other hand, thin film technology materials are direct band gap materials and hence needs comparatively thinner layer of material is required. Also they have high absorption coefficient. But the module level efficiencies are only in the range of 8% to 9%. Various Solar photovoltaic system applications are as follows,

- Stand alone systems such as solar battery charger.
- Solar vehicles.
- Building systems.
- Solar power plants.
- Decentralized grid connected systems.
- Space applications.
- Street lighting.
- Rural electrification where load shading is much more.

II. BATTERY

- It converts the chemical energy into the electrical energy through the chemical reaction.
- Power electronics circuit is used in pv charge controller to get highest efficiency, availability, and reliability.
- The size of the battery bank will depend upon storage capacity, maximum discharge rate and charge rate and also minimum temperature at which batteries will be used.
- Rechargeable batteries are widely used in standalone PV to store energy and supply to the load.
- When it is over charged it become disconnected without damage.

• There are two types of batteries:
Primary batteries: primary batteries can store and deliver electrical energy, but cannot be recharged.
Secondary batteries: a secondary battery can store and deliver energy, and also be recharged by passing a current through it in opposite direction to the discharge current.

Battery Type	Cost	Deep Cycle Performance	Maintenance
Flooded Lead-Acid			
Lead-Antimony	low	good	high
Lead-Calcium Open Vent	low	poor	medium
Lead-Calcium Sealed Vent	low	poor	low
Lead Antimony/Calcium Hybrid	medium	good	medium
Captive Electrolyte Lead-Acid (VRLA)			
Gelled	medium	fair	low
Absorbed Glass Mat	medium	fair	low
Nickel-Cadmium			
Sintered-Plate	high	good	none
Pocket-Plate	high	good	medium

Fig- Battery type and their properties

III. BATTERY CELL COMPOSITION

- Alkaline batteries are a type of primary battery dependent upon the reaction between zinc and manganese (IV) oxide (zinc/mno2). A rechargeable alkaline
- Battery allows reuse of specially designed cells.
- The alkaline battery gets its name because it has an alkaline electrolyte of potassium hydroxide, instead of the acidic ammonium chloride or zinc chloride electrolyte of the zinc-carbon batteries. Other battery systems also use alkaline electrolytes, but they use different active materials for the electrodes.

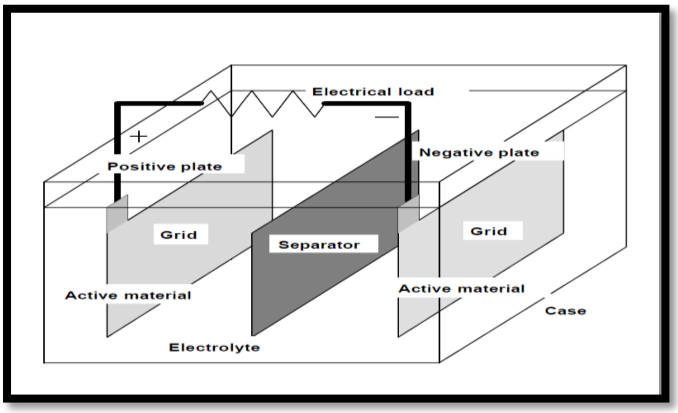

Fig battery Configuration

- Alkaline batteries are used in many household items such as mp3 players, cd players, digital cameras, pagers, toys, lights, and radios, to name a few.
- In an alkaline battery, the negative electrode is zinc and the positive electrode manganese oxide. The alkaline electrolyte of potassium hydroxide is not part of the reaction, only the zinc and manganese oxide are consumed during discharge. The alkaline electrolyte of potassium hydroxide remains, as there are equal amounts of oh− consumed and produced.

The half-reactions are: -
Zn(s) + 2OH−(aq) → ZnO(s) + H2O(l) + 2e− [e° = 1.28 V]
2MnO2(s) + H2O(l) + 2e− → Mn2O3(s) + 2OH−(aq) [e° = +0.15 V]
OVERALL REACTION :
ZN(S) + 2MNO2(S) ZNO(S) + MN2O3(S) [E° = 1.43 V]

PHOTOVOLTAIC CELL

- Photovoltaic (PV) is the field of technology and research related to the application of solar cells for energy by converting sun energy (sunlight or sun ultra violet radiation) directly into electricity. Due to the growing demand for clean sources of energy, the manufacture of solar cells and PV arrays has expanded dramatically in recent years.
- PV is best known as a method for generating electric power by using solar cells packaged in PV modules, often electrically connected in multiples as solar PV arrays to convert energy from the sun into electricity.
- The term PV denotes the unbiased operating mode of a photodiode in which current through the
- Device is entirely due to the transduced light energy.
- Virtually all PV devices are some type of photodiode. Solar cells produce direct current electricity from light, which can be used to power equipment or to recharge a battery. The first practical application of PV was to power orbiting satellites and other spacecraft, but today the
- Majority of PV modules are used for grid connected power generation.

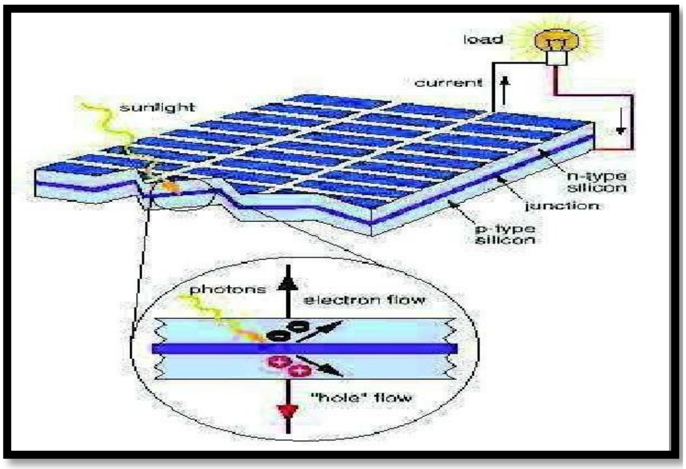

Fig: Solar PV generation system

- Above the diagram of pv cell in which when photons in sunlight hit the panel and absorbed by semiconducting materials, such as silicon.
- Electrons and protons are exicted.once excited electron can either dissipate the energy as heat and return to its orbital or travel through the cell until it reaches an electrode.
- An array of solar cells converts solar energy into direct current (dc).
- An inverter can convert the power to alternating current (ac).

Photovoltaic charger control

- PV modules are arranged in series and parallel to meet the energy requirements. A pv array consists of several photovoltaic cells in series and parallel connections. Series connections are responsible for increasing the voltage of the module whereas the parallel connection is responsible for increasing the current in the array.
- In PV system battery is functional and reliable component to achieve low cost and benefit that user can get from it.
- A charge controller is needed in photovoltaic system to safely charge sealed lead acid battery. The most basic function of a charge controller is to prevent battery overcharging. If battery is allowed to routinely overcharge, their life expectancy will be dramatically reduced.
- A charge controller will sense the battery voltage, and reduce or stop the charging current when the voltage gets high enough. This is especially important with sealed lead acid battery where we cannot replace the water that is lost during overcharging. Unlike wind or hydro system charge controller, pv charge controller can open
- The circuit when the battery is full without any harm to the modules.
- Most PV charge controller simply opens or restricts the circuit between the battery and PV array when the voltage rises to a set point. Then, as the battery absorbs the excess electrons and voltage begins dropping, the controller will turn back on. Some charge controllers have these voltage points factory-present and non adjustable, other controllers can be adjustable.

IV. BUCK-BOOST CONVERTER

BUCK (STEP DOWN) CONVERTER

- A buck converter is called a step-down DC to DC
- Converter because the output voltage is less than the input voltage. Its design is similar to the step-up boost converter, and like the boost converter it is a switched-mode power supply that uses two switches (a transistor and a diode) and an inductor and a capacitor.
- A buck converter can be remarkably efficient

(easily up to 95% for integrated circuits) and self regulating.

- Most buck converters are designed for continuous-current mode operation compared to the discontinuous-current mode operation. The continuous-current mode operation is characterized by inductor current remains positive throughout the switching period.
- Conversely, the discontinuous-current mode operation is characterized by inductor current returning to zero during each period.

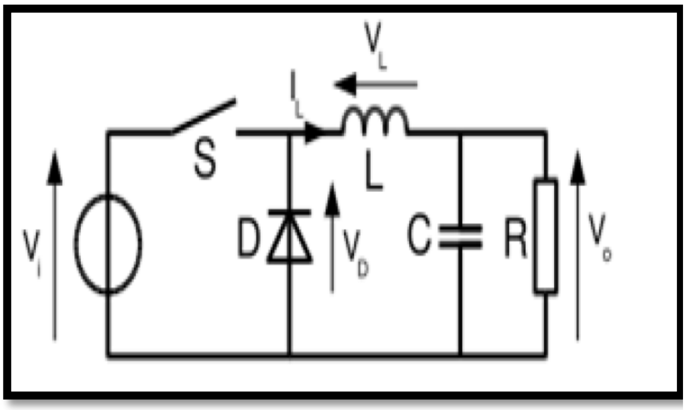

Fig -BUCK CONVERTER

Basic Operation of Buck Converter
Method 1: During ON state

- When the switch is in ON state, diode become as reversed biased and the inductor will deliver current. With the voltage across the inductor, the current rises linearly, The current through the inductor increase.
- As the source voltage would be greater then the output voltage and capacitor current may be in either direction depending on the inductor current and load current. When the current in inductor increase, the energy stored also increased.

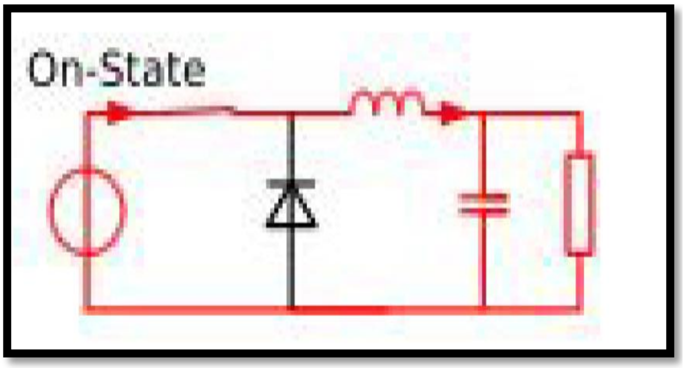

Fig Equivalent circuit when switch closed

Method 2: During OFF state

- When the switch is in OFF state, the diode is ON and the inductor will maintains current to load. Because of inductive energy storage, iL will continues to flow.
- While inductor releases current storage, it will flow to the load and provides voltage to the circuit. The diode is forward biased.
- The current flow through the diode which is inductor voltage is equal with negative output voltage.

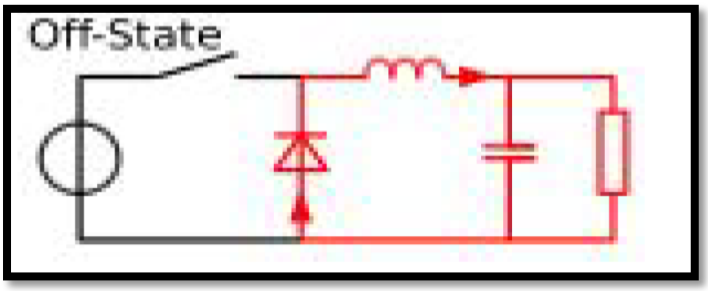

Fig - Equivalent circuit when switch open

BOOST (STEP-UP) CONVERTER

- A boost converter is called a step-up DC to DC converter because the output voltage is greater than the input voltage.
- It is a class of Switched mode power supply (SMPS).containing at least two semiconductors (a Diode and a Transistor) and at least one energy storage element (Capacitor, Inductor or Two in combination).

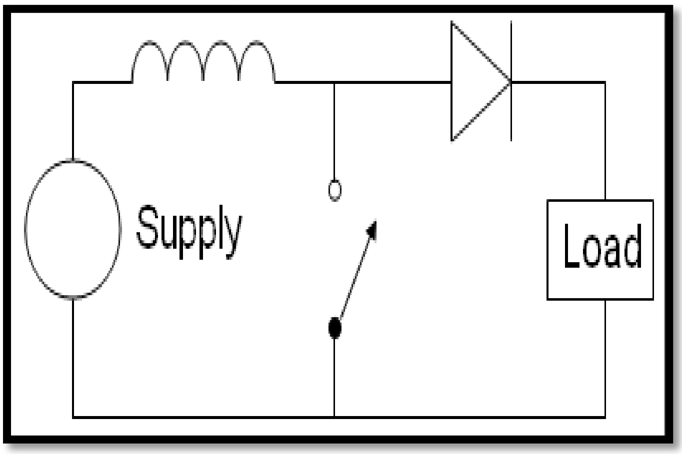

Fig- Boost Converter

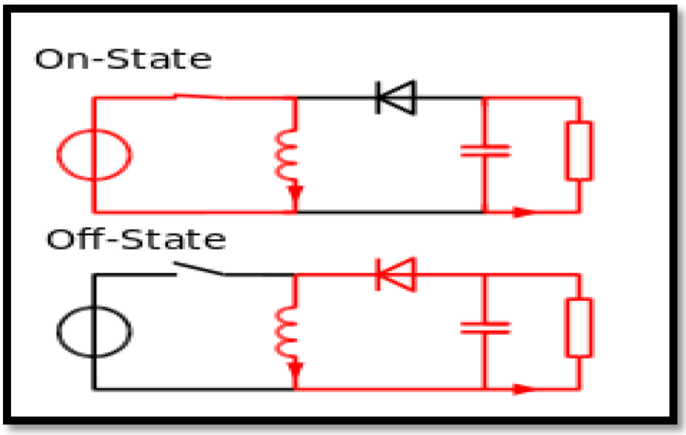

Fig -boost converter during ON-OFF condition

Basic Operation of Boost Converter

Continuous Mode: When boost converter operates in continuous mode then inductor never falls to zero.

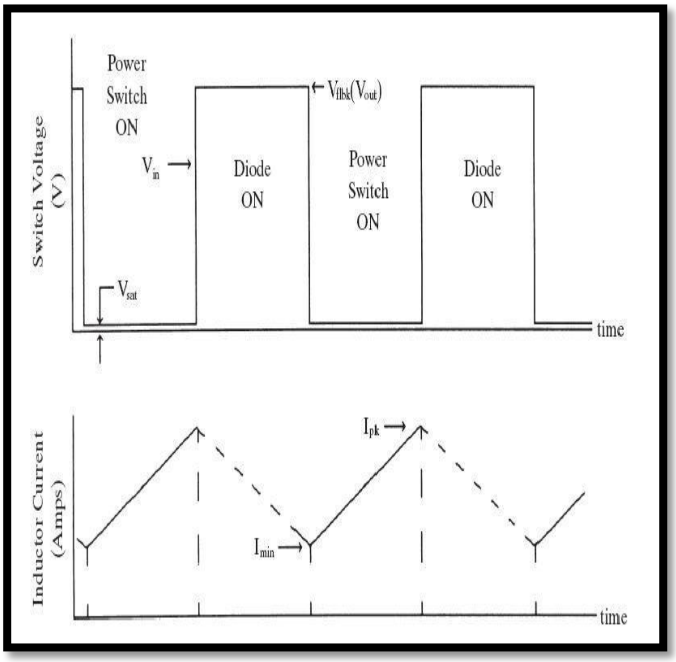

Fig Wave forms of current and voltage in boost converter during continuous mode

During the on state, Switch S is closed. Which makes the input voltage (Vi) appears across the inductor. Which causes a change in current (Il) following thorough the inductor during time period (t) by the formula: -

$$\frac{\Delta Il}{\Delta t} = \frac{Vi}{L}$$

Discontinuous Mode: If the ripple amplitude of current is too high, the inductor may be completely discharged before end of whole commutation cycle. This commonly occurs under light load.

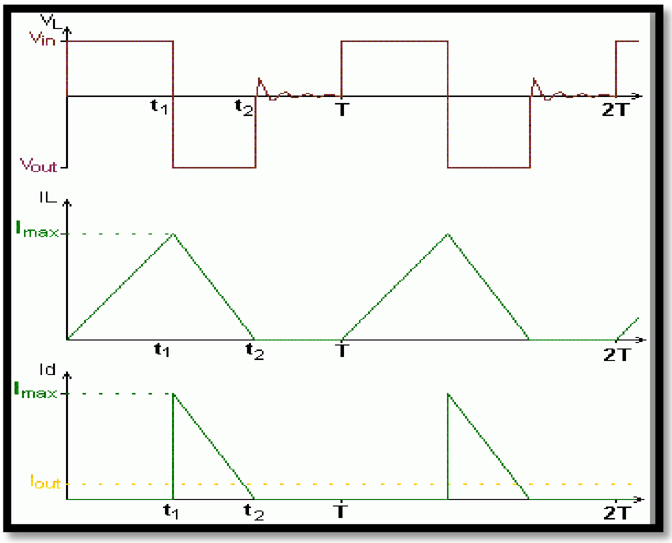

Fig- Boost converter under Discontinuous mode

V. SIMULATION AND RESULTS

model of solar inverter

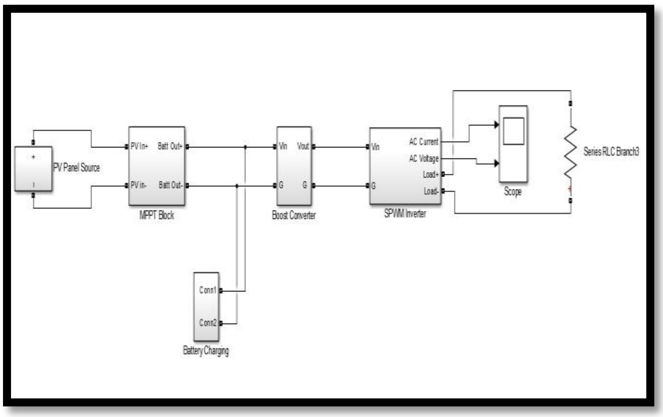

Fig- MATLAB model of Solar Inverter

battery connection

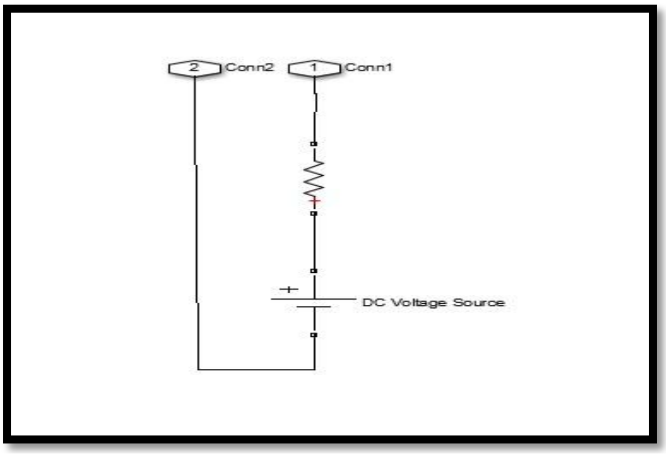

Fig- Battery Connection

model of dc-dc converter

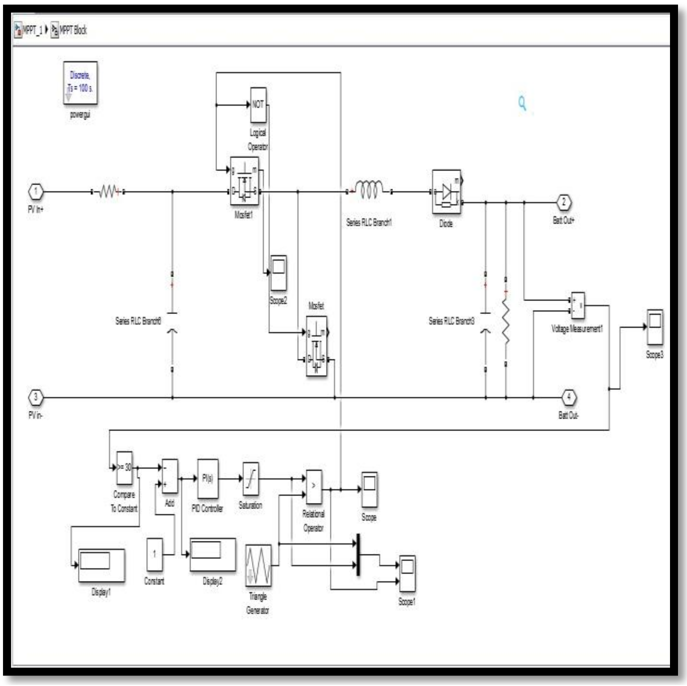

Fig- MATLAB model of DC-DC converter

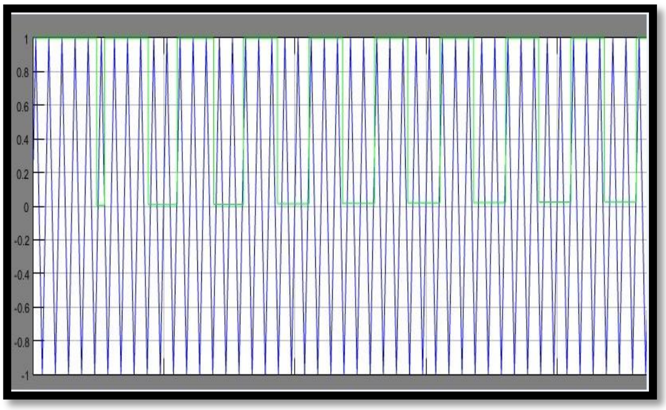

Fig -input signal for dc-dc converter

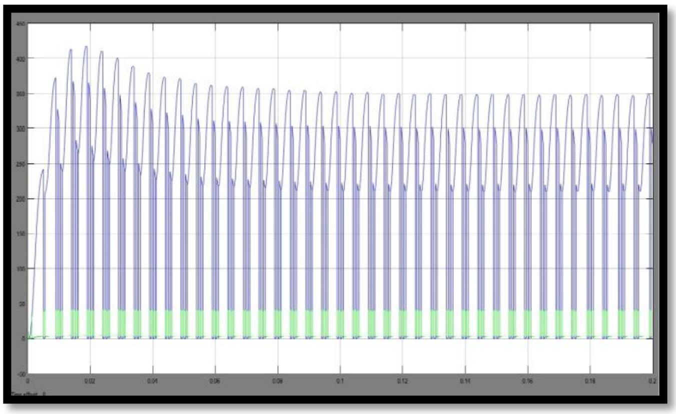

Fig- MOSFET output signal

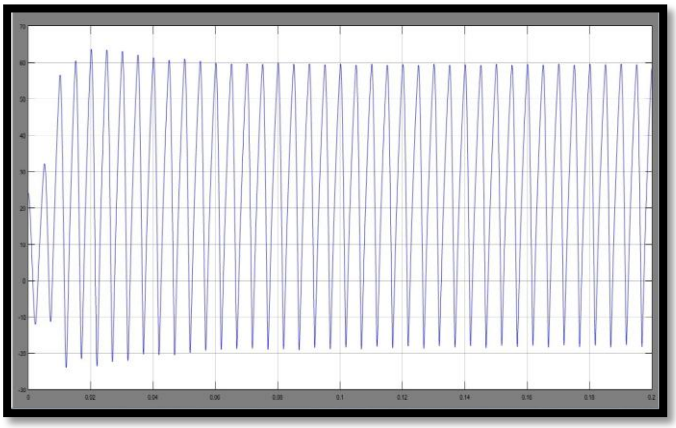

Fig- output voltage of dc-dc converter

VI. CONCLUSION

The purpose of this paper is Balance the system by the battery charge controller taking input from the MPPT result, also to increase the system's efficiency. Battery Charge Controller Is The Best Way To Save Power In Solar System .When Panel Is Not In Use At It Can Draw The Power From It And Supply Efficient And Reliable Power and make load continues in use also in night duration. By using Synchronized Buck converter it can take output of MPPT as a input and make it in continuous DC supply. While panel is not in used so by battery it can draw the power without any interruption.

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