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SOLAR POWER GENERATION USING OFF GRID SYSTEM

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Abstract - *The demand of electrical energy is increasing day by day and the same time sources of conventional energy are decreasing. In order to across the gap between the increasing demand and production some alternative energy resources have to be utilized. A renewable energy resource appears to be a bright solution. Solar energy is the best option because of its natural availability, clean, environmental friendly and infinite source of energy. The solar photo voltaic systems can be classified in two types: off-grid and on-grid systems. The result of a solar photovoltaic system depends on various factors such as irradiation, temperature. To judge the value of the existing system is very important for the characterization of the existing problems and for its future scope. To calculate the value of off grid photovoltaic system, model is prepared in a MATLAB/SIMULINK. The main motive of this study is to calculate the power and voltage levels, charging and discharging trends of the battery bank.*

Key Words: **Matlab, Simulink, boost, off-grid systems, photovoltaic, PMDC**

1. INTRODUCTION

Renewable energy sources like solar, tidal and wind is being exploited for the energy generation as they are clean and natural source of energy. Solar energy field is the best choice for Indian peninsula. The electricity generation target was fixed as 1137.5 Billion Unit (BU) for the year 2015-2016 i.e. growth increases 8.47% over actual generation of 1048.673 for the previous year (2014-2015). The required installation capacity by 2030 would reach 772GW. [1]The PV cells permit two type of installations either standalone or grid type power plant. During 2015-16, Off Grid and Decentralized Solar applications Program project capacity of 191.158mw is calculated. The stand-alone home systems would provide power for small houses up to 1 kwh or through the installation of a power plant in the village which would lighten up all the houses as well as community centre and street lights. [2] India has total solar PV installed capacity around 5547MW till Feb. The solar PV system is depends upon many factors like the irradiation and temperature. [4]But the overall system efficiency is a function of the performance of various components in the system such as array, MPPT, converter, storage device. [3] Explains how the atmospheric conditions affecting the output of a system. Every system should study based on some generalized parameters [3]. The development of a solar photovoltaic system is explained in MATLAB. Difference between a standalone and a grid connected system is the energy storage. Standalone system stores the surplus energy in the storage system like battery while the grid connected system injects the energy produced to the grid. [5-6]This paper is divided in to two parts. The first part includes the modeling of various components and the second part contains of the simulation results.

2. DESCRIPTION OF SOLAR OFF GRID SYSTEM:

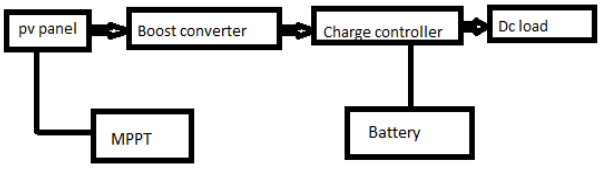


Fig: Electric generation from off grid system.

A. PV PANEL:

A PV module is constituted by arraying a group of many tiny cells. A PV cell is a P-N junction formed from a semiconductor material usually silicon or germanium. When the cell is exposed to solar radiation the electron hole pair is formed in the cell. Due to internal electric field drift is sustained. If the terminals

of the cells are short circuited, current will flow in the circuit. (Current through cell is known as short circuit current) [7]. If the terminals of the cells are open circuited current generated is shunted through a diode connected in parallel with the cell (its terminal voltage is known as open circuit voltage).

The simplest equivalent circuit of a solar cell is a current source in anti-parallel with a diode as in figure1. The output of the current source is directly proportional to the light falling on the cell (photocurrent Iph). [8]

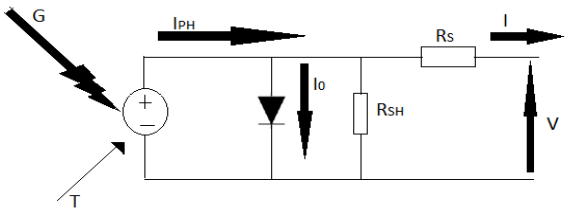


Figure 1: Single diode model of a solar cell [9]

Applying Kirchhoff's current law, we get [10]

$I_{ph}=I_0+I_{Rsh}+I$ (1)

We get the following equation for the photovoltaic current:

$I= I_{ph}-I*R_{sh}-I_o$ (2)

$I = I_{ph} -I_o* [(\exp^{(V+I.Rs)/VT)}-1]-[(V+I.R_s)/R_{sh}]$ (3)

Where, I_{ph} is denoted as Isolation current, I is represent the cell current, Io is the Reverse saturation current, V is the voltage of cell, Rs is the resistance of series,[11] VT is represents the Thermal voltage (KT/q), K is denoted as Boltzmann constant, T is denoted as Temperature in Kelvin, q is the Charge of an electron.

B. BOOST CONVERTER:

A step up converter or boost converter is a DC to DC converter steps up voltage (while stepping down current) from its supply to its load . It is a class of switched-mode power supply (SMPS) containing diode and transistor and at least one energy storage element from a capacitor, inductor, or the two in combination. To reduce voltage ripple, filters made of capacitors and sometimes in combination with inductors are normally added to such a converter's output (load-side filter) and input (supply-side filter).[12]

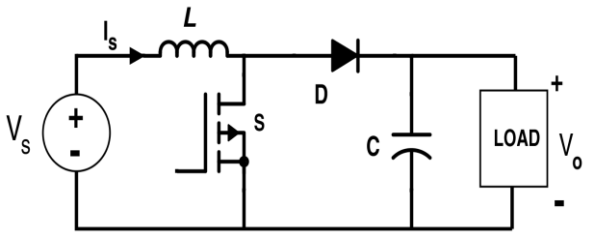


Fig 2: Boost converter.

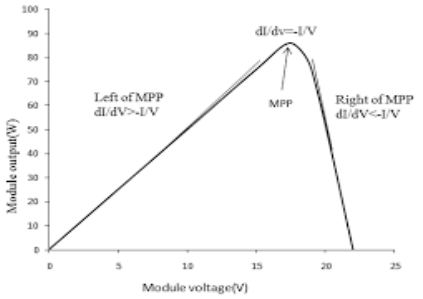
C. PERTURB AND OBSERVE METHOD

The "Perturb and Observe" is the algorithm of MPPT which is used to modify the operating voltage or current of the photovoltaic (PV) system until the maximum power point is achieved. For example, if the voltage is increasing on a panel then the output power of a panel is also increasing, then the PV system increases the operating voltage until the output power starts to decrease. When this stage comes, then the voltage is continuously decreasing up to the maximum output power comes [19] and this process is continued until the maximum power point is come. Thus, the value of power output is approximately oscillates around a maximum power point until it stabilizes. Perturb and observe is the maximum used MPPT method due to its ease or effective enforcement. The major disadvantages of the perturb and observe method is that in the steady state the operational power oscillates around the maximum power point. Also, this algorithm can track a wrong path, when the changes in irradiance levels happening quickly. [20]

D. INCREMENTAL CONDUCTANCE MPPT ALGORITHIM:

In this method Incremental conductance is the operating point for a PV panel which synchronize with its maximum power output can be expressed as mathematically:

$$\frac{Ipv}{Vpv} = -\frac{dIpv}{dVpv}$$



Graph 1: incremental conductance

Where Ipv and Vpv are the photovoltaic (PV) panel's terminal current and voltage. Unlike, the maximum power point (MPP) for a PV panel equal to running condition where the negative of the incremental conductance is equal to high signal conductance.[24] To achieve maximum power output from a Photovoltaic (PV) panel the incremental conductance method feat this requisite by utilizing a controller to attain the relationship in , is a technique that takes the benefit that the slope of the Power voltage curve is zero at the maximum power point. At the left of the MPP the power voltage curve of the slope is positive and at the right of the MPP is negative. [25]

E. CHARGE CONTROLLER:

Blocking diodes and battery voltage regulators, i.e. used in power conditioning and regulation units are called charge controller. The diodes block the batteries to discharge through the solar cells as well as protects from short circuits in the solar cells. The charge controllers protect the batteries by limiting the discharge levels and overcharging.

F. BATTERY:

There are many different types of batteries are currently available on the market and within the research areas. Even there is a wide range for the batteries of similar technology of efficiency and lifetime values. For stand-alone systems the most common is lead-acid batteries. The main desirable requirements for batteries are that they should have low losses, small temperature rise, self- discharge very low long lifetime, long duty, high charge storage efficiency, low cost and easy maintenance. There are several main characteristics of batteries. The capacity of battery is measured in Ah or KWh at a constant discharge rate.) The efficiency of stand-alone PV systems varies between 80-95 %, and depending on how well they are maintained the efficiency can quickly decrease. How deep the battery is discharged is named Depth of Discharge, and batteries can have a depth of discharge up to 80 %. The batteries could also be sealed or unsealed. They need less maintenance is the advantage of sealed batteries, and they are also spill-proof and do not emit corrosive fumes. The disadvantages of this battery that they are in general more expensive need more accurate charging control and may have a shorter lifetime, especially for higher temperatures.

G. DC LOAD:

In PV water pumping applications two types of pumps are commonly used for: positive displacement and Centrifugal pumps. The low volume pumps and cost-effective are used in positive displacement types. Centrifugal pumps also have relatively high efficiency and also capable of a high volume water for pumping. At least 500W or larger is a typical size of system with this type pump. There is a increasing trend among the pump manufacturers to use brushless DC motors for higher efficiency and low maintenance.[15] However, the cost and complexity will be significantly higher of these system. Water pumps are driven by different types of motors. AC induction motors are available worldwide because of its cheaper and widely property. The system needs an inverter to convert output power of DC from PV panel to AC power which is usually expensive, and less efficient than DC motor-pump systems. DC, motors are preferred because they are highly efficient and can be directly coupled with a PV module. Brushed type is less expensive and more common although brushes need to be replaced typically every two years. That's why a permanent magnet dc motor (PMDC) is used. PMDC system converts electrical power provided by a voltage source to mechanical power provided by means of magnetic coupling with spinning rotor. The armature coil of the DC motor can be represented by Lm an inductance in series with Rm resistance and with a(em) series induced voltage, which opposes the voltage source. A differential equation for the equivalent circuit of dc

motor can be derived by using Kirchhoff's voltage law around the electrical loop.[16]

Vm (k) = Rm Ia (k) + Lm d Ia (k) / dt + em (k) (4)

The water pump chosen here is submersible solar pump for its size and cost.

III SIMULATION RESULTS:

A. MODELLING OF PV ARRAY WITH BOOST CONVERTER USING MPPT

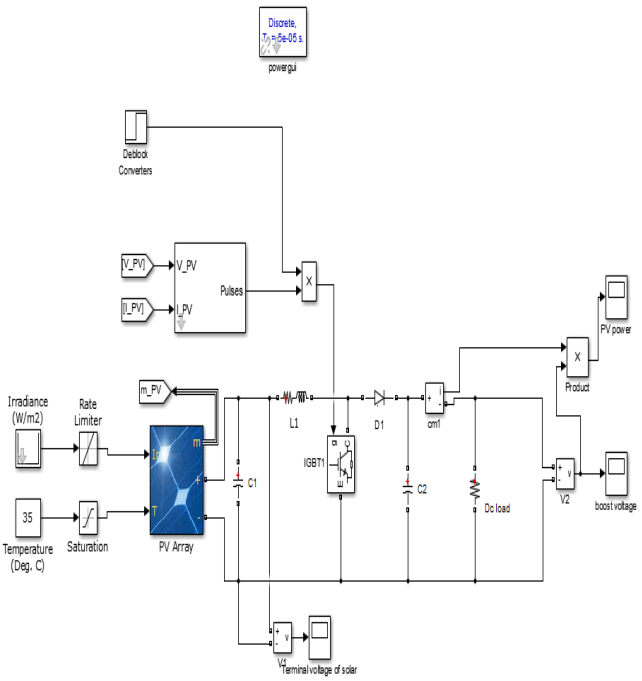


Fig: simulation of pv array using mppt.

The PV array consists of 40 strings in parallel and 700 series connected modules per string connected in series .The boost converter connected with PV Array and operated by MPPT controller after 0.1 s. Specifications for PV Array are: Short circuit current: Isc= 3.27 Open circuit voltage: Voc= 400 V. Voltage and current at maximum power Vmp:= 395.8V,Imp= 2.78A.The initial voltage is obstinate at 250 V for the IC.

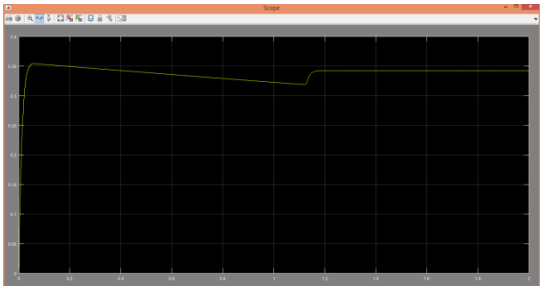


Fig: output with PWM

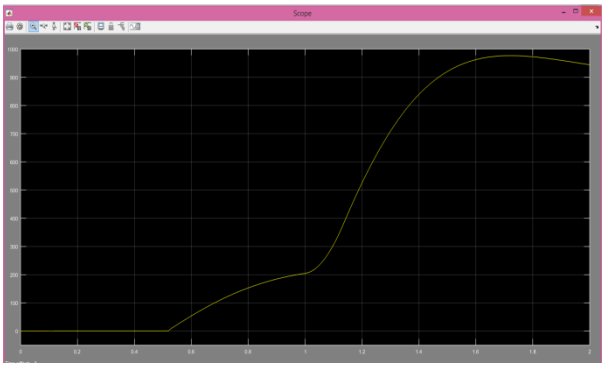


Fig: output with incremental mppt

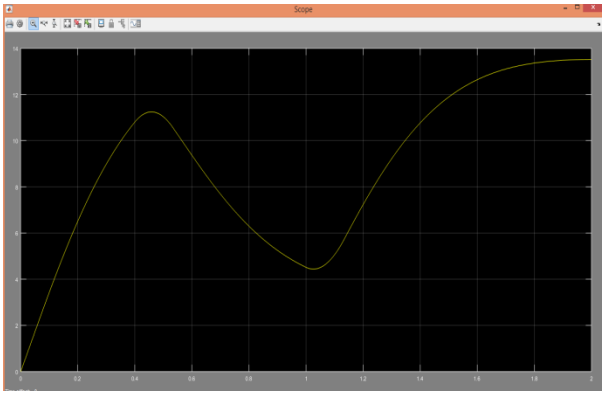


Fig: output with p and o mppt

B. BATTERY WITH CHARGE CONTROLLER:

The battery capacity is measured in ampere-hours (Ah) or kWh at a constant discharge rate. (If a battery should be able to produce energy on one day i.e not sunny it needs to have more capacity installed than what the load requires during one day. This is called autonomy). In which we have 4800/746= 6.4h something time to discharge. The efficiency of stand-alone PV systems varies between 80-95 %, and depending on how good they are maintained the efficiency can decrease. The charge controllers protect

the batteries by limiting the discharge levels and overcharging. The main desirable requirements for batteries are that they should have very few losses, small temperature rise, self- discharge very low long lifetime, long duty cycle (have long periods of low charge), high charge storage efficiency, low cost and easy maintenance.

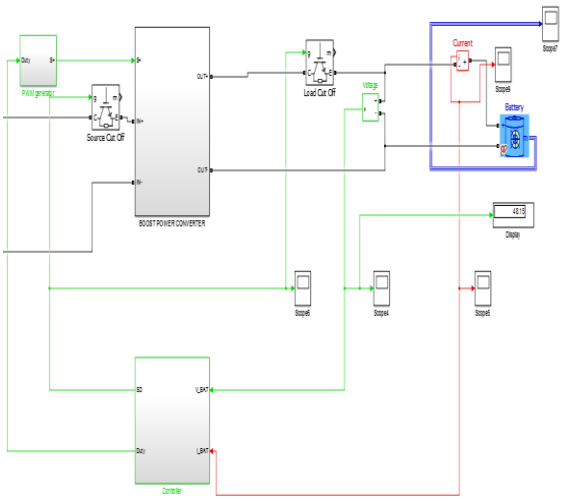


Fig: Battery with charge controller

Result of charging current and charging voltage from battery with the help of charge controller and pv panel.

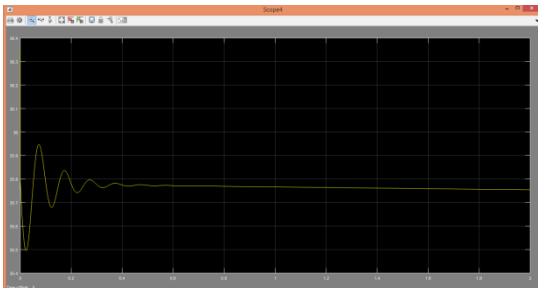


Fig: discharge from battery voltage PWM

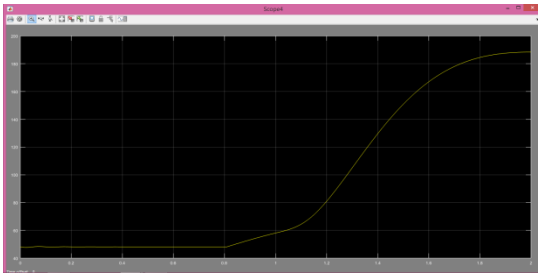


Fig: discharge from battery voltage incremental

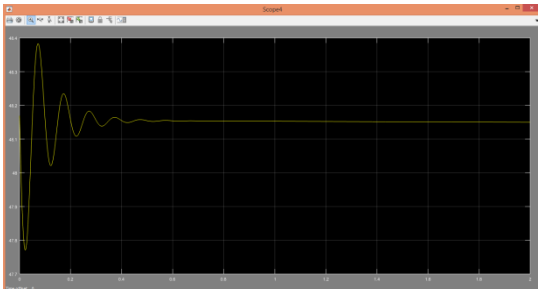


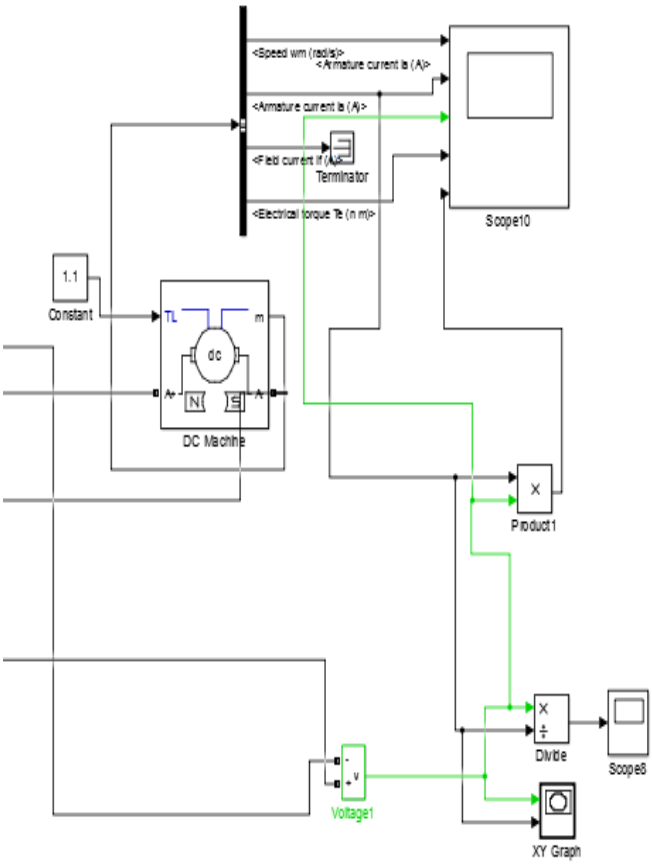
Fig: discharge from battery voltage p and o

The array of PV modules produces DC and the amount varies depending on the design. When several solar cells are attached together the construction is called a module. The modules can be constructed in several ways in order to meet different demands within electricity production at different voltages. The cells can be connected in both parallel and series connections but will produce DC.

C. MODELLING OF PMDC MOTOR PUMP:

The water pump chosen here for its size and cost is submersible solar pump. It is diaphragm-type positive displacement pump equipped with a brushed permanent magnet DC motor and designed for use in standalone water delivery systems, specially for water delivery in remote locations.

Fig: Permanent magnet dc motor pump



- Result of PMDC motor:

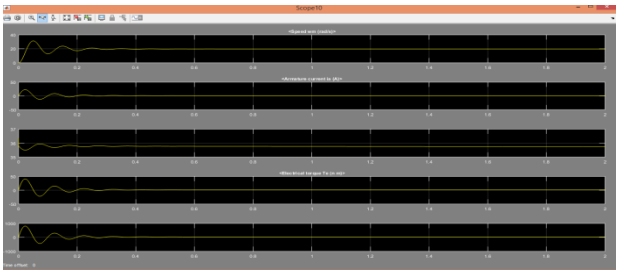


Fig: output using PWM

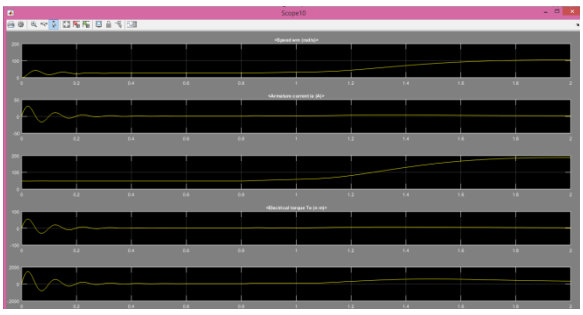


Fig: output using incremental

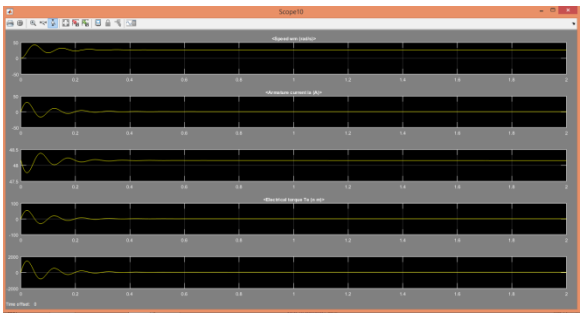


Fig: output using p and o

CONCLUSIONS:

An off grid PV system for dc load is modeled and simulated in Matlab Simulink. Its major applications are in rural and remote area electrifications. Load profile calculated by ratings of the electrical appliances commonly used in a house and then according to load rating of components of off grid PV system is calculated than system is simulated in Matlab. Solar array modeled with mathematical equations of solar cell and also other components like buck and boost converter also modeled with the help of equivalent circuit of these. Off grid PV system simulated on standard operating conditions i.e. 1kW radiations and 35 degree celsius temperature and also on varying operating conditions (seasonal variations).

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