PHOTOVOLTAIC DISTRIBUTED GENERATION USING MPPT ALGORITHM WITH BATTERY STORAGE

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Abstract : ***The distributed energy sources are commonly used small energy generating sources Renewable resource of energy such as photovoltaics are commonly used for generating power as demand is increasing. Solar cells are the building block of PV array. Different types of MPPT methods are developed for extracting the maximum power from the solar module. There are many MPPT algorithms and they are varying due to simplicity, efficiency, tracking speed, sensor required and cost. MPPT control already reduces wasted energy by operating the PV solar module at its higher MPP voltage and lower MPP current, instead of the lower power obtained by connecting the PV directly across the battery terminals. The main objective of this paper is to supply power to the load using renewable energy as source such as photovoltaics and battery as a backup and extracting maximum power from solar panel through maximum power point tracking technique using dc-dc converter.***

Key words— Maximum power point tracking (MPPT), Photovoltaics (PV), Distributed energy storage system (DESS), Distributed generation (DG), DC-DC Converter.

I. INTRODUCTION

Photovoltaics is the field of technology and research related to the devices which directly convert sunlight into electricity using semiconductors that exhibit the photovoltaic effect. Photovoltaic effect involves the creation of voltage in a material upon exposure to electromagnetic radiation.

A PV array consists of a number of PV modules, mounted in the same plane and electrically connected to give the required electrical output for the application. The PV array can be of any size from a few hundred watts to hundreds of kilowatts, although the larger systems are often divided into several electrically independent sub arrays each feeding into their own power conditioning system

Micro grid is a small grid, integration of large number of distributed generators. Microgrid is combination of generating units and energy storage units located close to load centers. Micro grid is widely used in generation systems, due to benefits of achieving high efficiency and increasing demand. Renewable resource of energy such as photovoltaics are commonly used for generating power as demand is increasing. Solar cells are the building block of PV array. When sunlight strikes solar cell it generates electricity. These cells are connected in series and parallel to form module.

Power conversion efficiency of solar module is very low. To increase the efficiency of solar module proper impedance matching of source to load is required. Different types of MPPT methods are developed for extracting the maximum power from the solar module. There are many MPPT algorithms and they are varying due to simplicity, efficiency, tracking speed, sensor required and cost. The V-I characteristics of the solar module is nonlinear and it mainly depends on irradiation and temperature.

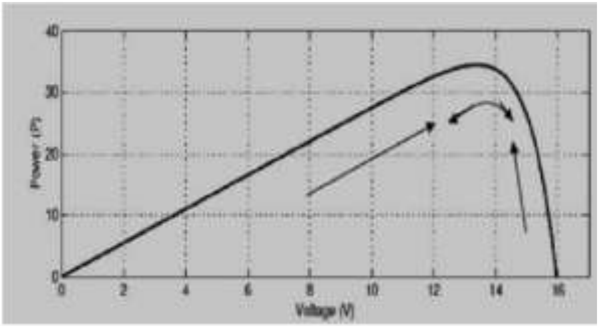
PV solar systems exist in many different configurations with regard to their relationship to inverter systems, external grids, battery banks, or other electrical loads. Regardless of the ultimate destination of the solar power, though, the central problem addressed by MPPT is that the efficiency of power transfer from the solar cell depends on both the amount of sunlight falling on the solar panels and the electrical characteristics of the load. As the amount of sunlight varies, the load characteristic that gives the highest power transfer efficiency changes, so that the efficiency of the system is optimized when the load characteristic changes to keep the power transfer at highest efficiency.

This load characteristic is called the maximum power point and MPPT is the process of finding this point and keeping the load characteristic there. Electrical circuits can be designed to present arbitrary loads to the photovoltaic cells and then convert the voltage, current, or frequency to suit other devices or systems, and MPPT solves the problem of choosing the best load to be presented to the cells in order to get the most usable power out. Solar cells have a complex relationship between temperature and total resistance that produces a non-linear output efficiency which can be analyzed based on the I-V curve. It is the purpose of the MPPT system to sample the output of the PV cells and apply the proper resistance (load) to obtain maximum power for any given environmental conditions. MPPT devices are typically integrated into an electric power converter system that provides voltage or current conversion, filtering, and regulation for driving various loads, including power grids, batteries, or motors.

Solar inverters convert the DC power to AC power and may incorporate MPPT: such inverters sample the output power (I-V curve) from the solar modules and apply the proper resistance (load) so as to obtain maximum power.

The power at the MPP (Pmpp) is the product of the MPP voltage (Vmpp) and MPP current (Impp). The V-I characteristics of the solar module is nonlinear and extremely affected by the solar irradiation and temperature. The Perturb and Observe (P&O) method algorithm is used for extracting maximum available power from PV module under various conditions.

The most commonly used MPPT algorithm is P&O method. In this algorithm a slight voltage change is introduce to the system, this change causes the power of the solar module varies. If the power increases due to the change then the change is continued in the same direction. After the peak power is reached, the power at the MPP is maximum and next instant decreases and hence after that the variation reverses as shown in Figure 1. When the stable condition is arrived the algorithm oscillates around the peak power point. In order to maintain the power variation small the change size is remain very small. A PI controller then acts to transfer the operating point of the module to that particular voltage level, some power loss due to this change also fails to track the maximum power under fast changing atmospheric conditions



. Fig (a): Graph showing power verses voltage for P&O algorithm

II.MODELING OF PHOTO VOLTAIC SYSTEM

The PV system consists of PV arrays and corresponding DC/AC converter modules. Generally, according to the sunlight conditions, the maximum power point tracking control mode is adopted for PV system, which aims to utilization of solar energy. When exposed to sunlight, photons which energy greater than the band gap energy of the semiconductor are absorbed and create some electron hole - pair proportional to the incident radiation.

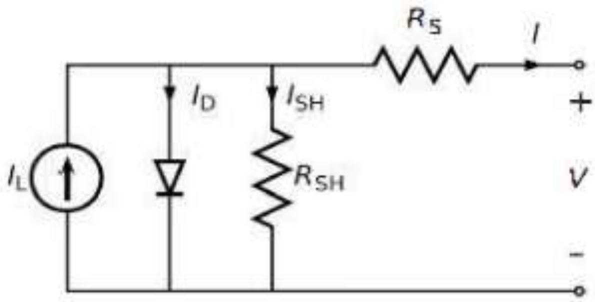


Fig. 2 Equivalent circuit of photovoltaic system

The equations of the output current is given by,

$$I = I_{PV} - I_D \quad (1)$$

$$I_D = I_0[exp\frac{V}{AV_T} - 1] \quad (2)$$

Then equation (1) becomes

$$I = I_{PV} - I_0[\exp\frac{V}{AV_T} - 1] \quad (3)$$

$$I = [\exp(\frac{V+I*R_S}{I_{PV}-I_0*V_T}) - 1] \quad (4)$$

$$P = V\{I_{sc} - I_0[\exp\left(\frac{V}{AV_T}\right) - 1]\} \quad (5)$$

Ipv is the current generated by the incident of light, I_o is the diode reverse bias saturation current, $V_T = N_S.K.T/Q$ is the thermal voltage of PV module having Number of cells (N_S) connected in series; R_s starting resistance, I_{sc} is the short circuit current, q is the electron charge; K = 1.38xl0-23 is the Boltzmann constant; T is the temperature of the p-n junction and A = 2 is the diode ideality factor. The output of the current source is directly proportional to light falling on the cell. Naturally PV system exhibits a non-linear Current - Voltage (I-V) and Power - Voltage (P-V) characteristics which vary with the radiant intensity and cell temperature. The dependence of power generated by a PV array with changing atmospheric conditions can readily be seen in the I-V and the P-V characteristics of PV arrays.

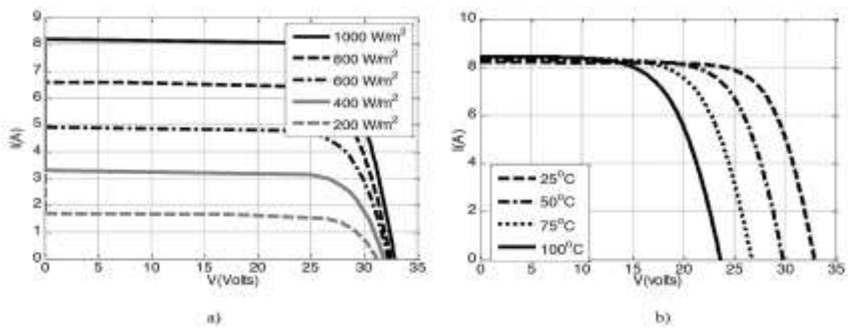


Figure 3.The I-V characteristics of solar module is shown with

(a) varying irradiance at a cell temperature of o 25 C

(b) Varying cell temperature at $1000W/m^2$

III.BATTERY MODELLING

Energy storage is able to perform multiple functions, such as ensuring power quality, including frequency and voltage regulation, smoothing the output of renewable energy sources, providing backup power to the system. The scientific modelled battery has two equations representing the battery discharge and charge model is given below:

$$V_{battery} = V_o - R*i - K\frac{Q}{(Q-it)}(it+t^*)+\exp(t)$$ …….. (6)

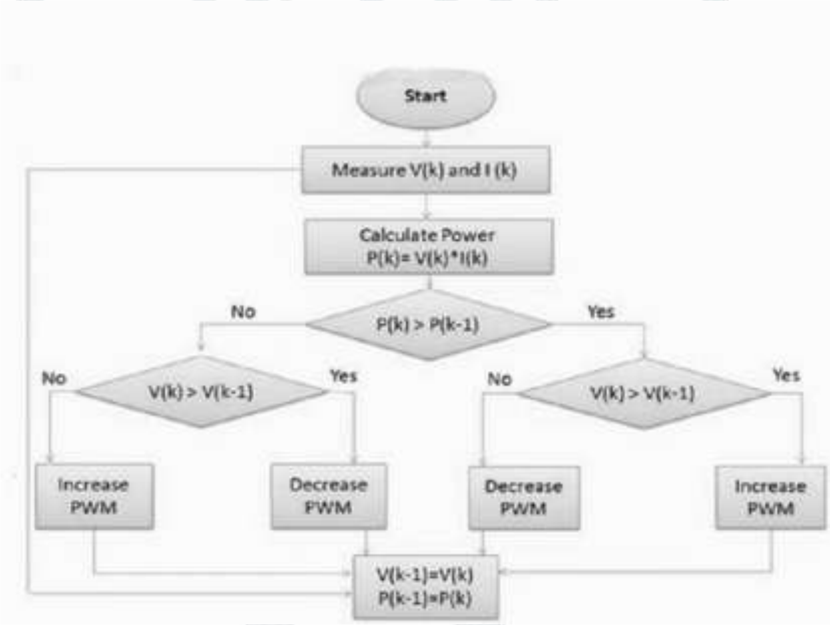
$$V_{battery} = V_o - R*i - [K\frac{Q}{it-0.1Q}]i^* - [K\frac{Q}{Q-it}]+\exp(t)$$ ……… (7)

Where V battery is the battery voltage (V), V_O is the battery constant voltage (V), K is polarization constant (V/Ah) or polarization resistance (Ω), Q is battery capacity (Ah), R is the internal resistance (Ω), i is battery current (A), and * i is filtered current (A).

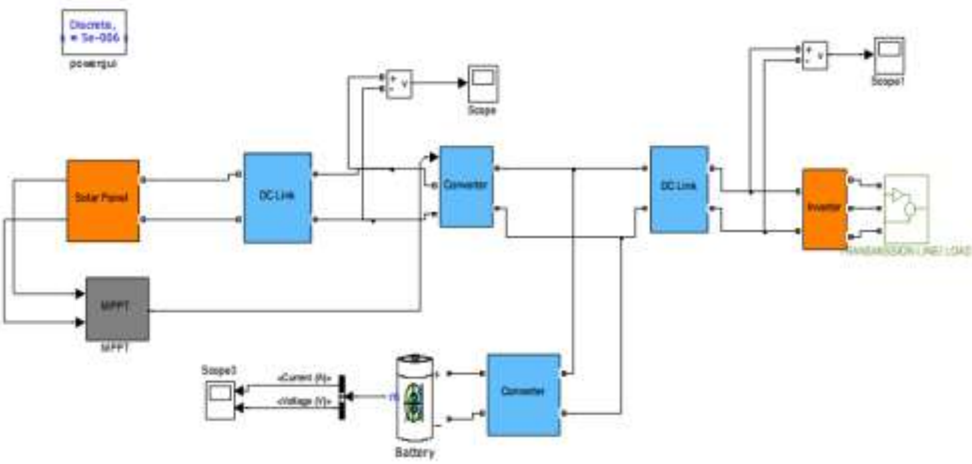
IV.CONTROL METHOD- ALGORITHM FOR P&O METHOD

Power conversion efficiency of solar module is very low, to increase efficiency of solar module proper Impedance matching of load to source is required. There are many MPPT algorithms and they differ due to simplicity, sensor required, tracking speed and cost. The V-I characteristics of the solar module is nonlinear and extremely affected by the solar irradiation and temperature.

The maximum power point tracking (MPPT) is algorithm used for extracting maximum available power from PV module under various conditions. The most commonly used MPPT algorithm is P&O method. In this algorithm a slight voltage change is introduce to the system, this change causes the power of the solar module varies. If the power increases due to the change then the perturbation is continued in the same direction. After the peak power is reached the power at the MPP is maximum and next instant decreases and hence after that the perturbation reverses as shown in Figure 1. When the stable condition is arrived the algorithm oscillates around the peak power point. In order to maintain the power variation small the perturbation size is remain very small. A PI controller then acts to transfer the operating point of the module to that particular voltage level, some power loss due to this perturbation also fails to track the maximum power under fast changing atmospheric conditions



V.SIMULINK MODEL:



Microgrid is a cluster of loads, micro sources, storage devices, for extracting maximum power from solar photovoltaic module maximum power point tracking algorithm is used so as to increase efficiency.

Perturb and Observe method is commonly used for extracting the maximum power from the PV module. It is simple and easy to implement. Due to change in irradiance step input is taken from PV module V_n and V_b is the step delay to limit drop in voltage or fall in voltage. Similarly for the current In is the step input taken from the PV module and I_b is the step delay to limit fall in current. P_n - P_b measures the power with feedback for reference is used, Similarly V_n - V_b measures the voltage with feedback for reference is used. If dP/dV=0 then switch is closed and maximum power is tracked. If dP/dV>0 or dP/dV<0 then there will be repeated cycle for tracking the maximum power.

RESULTS

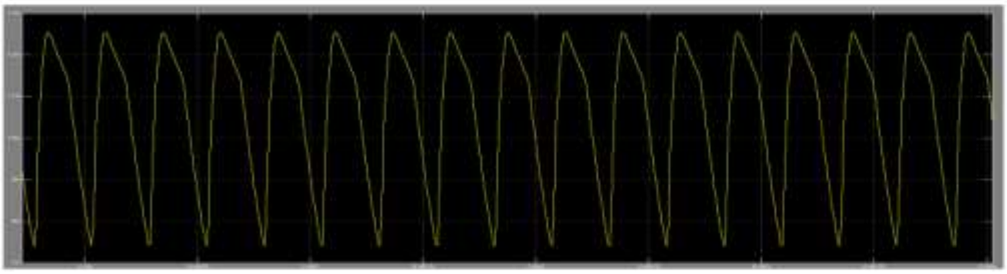


Fig.4 Waveform of the solar panel output voltage

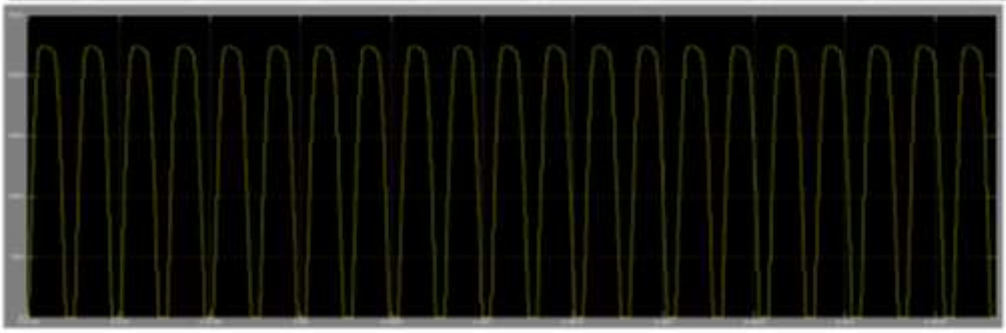


Fig.5 wave form of the battery

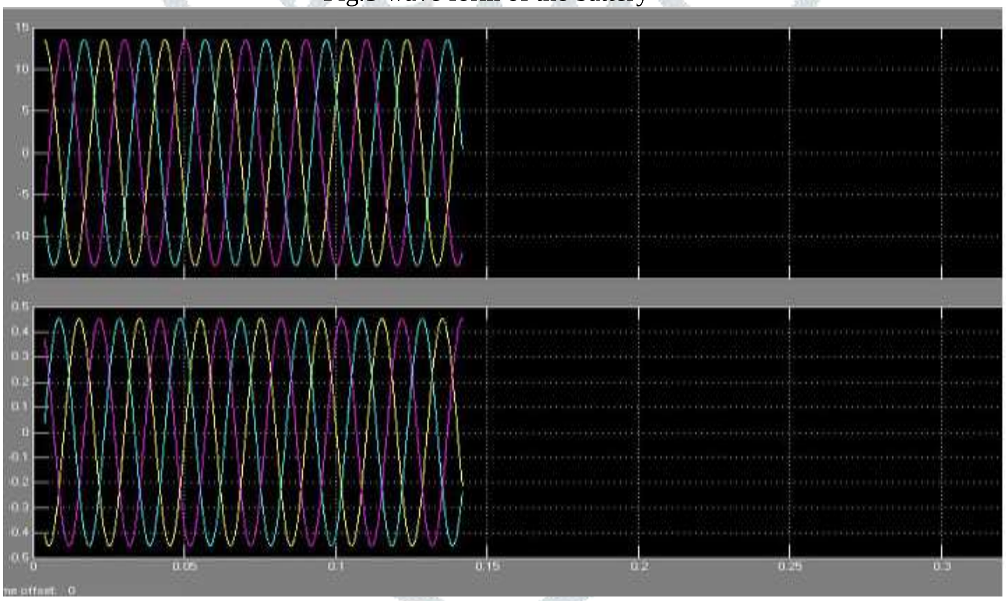


Fig.6 Waveform of inverter output

VI.CONCLUSION

This Paper develops the control strategy with efficacious coordination between PV generator, battery and inverter in micro grid for demand power management. PV generator gives maximum power through MPPT control using P&O method. A PI controller then acts to transfer the operating point of the module to that particular voltage level, some power loss due to this perturbation also fails to track the maximum power under fast changing atmospheric conditions. It shows the control strategy with coordination between PV generators, battery for V-f control. It also shows the soft synchronization.

A battery also employed in the plant to provide backup hence, by using P&O algorithm reduces the cost and increases the efficiency of the system and is highly competitive against other algorithms.

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