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Designing and Simulation of Solar Module in the Islanded Network of a Solar PV Micro Grid

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ABSTRACT--- This paper purposes the parameters and characteristics which has to be considered during the modelling of a photovoltaic panel in the islanded network of a solar photovoltaic micro-grid. The parameters which are taken into account are temperature and irradiance. Also the MPPT technique is used for the tracking of the solar radiations. For the study one should know that the photovoltaic cell considered as basic and important element for the conversion of light to electrical current. For designing and simulation of the photovoltaic cell, MATLAB software is used. Whenever there is any non- linear load, the photovoltaic cell is act as the active power filter. Moreover the harmonics thus induced is compensated by using PV-module. PV-cells deployed to achieve unity power factor at the grid side. The PV cell module is used in the manner that PV-cell functioning as distributed generator desegregated with the grid and operates the grid.

Keywords— photovoltaic cell, MATLAB, islanding, designing

I. INTRODUCTION

The electricity has considerably engrossed in the world over the last twenty years. Moreover, it is presume that the energy consume of the world will hike up to 56% in upcoming years due to the increase in energy demand for living a comfortable life. But we have to confront with two main challenges, that are: pollution emitted because of the excess use of fossil fuels, and furthermore these conventional resources are finite[1]. This increases the fear of energy crises due to the limited energy resources. So, there is increase in interest in the renewable resources. But renewable resources alone can't able to meet the demand. So, in order to overcome all the challenges, the integration techniques are used where the renewable resources is connect with grid so that the load on the system will be shared.

Amidst of all sustainable energy assets solar energy is the best energy assets. As it is more efficient and highly reliable. Moreover it has long life span plus clean energy resource. Furthermore, it is considerably one of the most sustainable energy resources and can be available easily and everywhere.

The Sun generates 3.8x1020 MW of electromagnetic energy, which reaches to earth as solar energy. Solar irradiance is defined as the solar power received per unit area; an average of 1.377kW/m2 can be measured outside the atmosphere of earth. On a clear day, 70% of sun's energy reaches to the earth's surface, which is defined as the sun insolation. The sun's energy can be utilized in two forms: thermal solar energy and photovoltaic (PV) energy. PV energy is the electrical energy which is obtained by converting solar radiation into electricity using photovoltaic cells. Due to rise in energy demand globally and also the environmental threats about limited fossil fuels has increased the hunt for eco-friendly, renewable assets. Photovoltaic energy, which is found to be eco-friendly and viable in comparison with other energy sources, has acquired immense importance in coming years. The boost in demand of PV power has resulted in increases in research to enhance the performance of the PV system. The researchers has mainly fascinates the DC side of the photo-voltaic arrangement, where many new algorithms have been proposed to increase energy yield and new topologies are formed to increase efficiency.

The photovoltaic module is the merger of number of photovoltaic cell in series and shunt. The factors affecting PV-Characteristics (current, output power and voltage) are temperature and irradiance and both the parameters vary according the climatic conditions [2].

Many approaches taken which foster the use of the solar energy for both the commercial as well domestic users, reduced the price of electricity and also after some time the PV system payback which is the foremost trouble for the PV system, which help and aid the energy generated system hence make the system much better in case of cost oriented issues as that of conventional energy resources. To meet the above aim, a lot of attempts and for technical developments in this fields a lot of developments are needed, such as:

- Manufacture Elements: This lead to decrease in the manufacturing cost of the cell and helps in increasing in the efficiency of the cells, sensors, switches and batteries.
- Control power converters: The improved technique is used in order to supress the harmonics caused due to current and voltage.
- Management of power: For managing the flow of power either between the single PV system components or any hybrid system the reliability is high, it also increases efficiency and cost also reduces [1].

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II. PHOTOVOLTAIC CELL

There is a vital role of buildings in balancing the global energy, because they are responsible for 20 - 30% of the industrialized countries energy consumption. The technology of photovoltaic can contribute significantly towards an environmentally friendly design of buildings. Photovoltaic can generate electricity from sunlight using cells. Photovoltaic modules are devices that convert solar radiation into electricity without producing any pollution or don't require any kind of fuels for their operation. Photovoltaic technology can produce power from milliwatts to megawatts and it is cost-effective for remote applications. At present, PV modules have a life about 25 to 30 years. Due to the rapid improvement in technology and the need for sustainable energy design the use of PVs in buildings shows promise of great growth.

Solar cells are the fundamental unit of a photovoltaic panel and thus, this is used as the component for converting the rays of sun into electric power.

The layout of grid connected PV-System consisting of DC step up converter, PV-Module, VSI with three legs, three phase AC source and loads. The design of PV system is in such a way that the peak power so derived is 36.6KW and a DC to DC converter is connected that helps in boosting Voltage of PV cell from 330-350V to 670-700V [3].

The PN union is used by the solar cell, which has different attribute very from that of a diode, the Shockley equation (1) represent it. So, the method of modelling the solar is fabricated by using equations (1), (2) and (3).

$$I_d = I_o[\mathrm{e}^{\frac{vcq}{aktck}} - 1] \quad (1)$$

here:

- "I_D"- dark current (A),
- "I_0"–diode's saturated current (A),
- "V_C"-voltage of cell (V),
- "q"-electron charge, equal to $1.6\mathrm{x}10^{-19}$ (Columbus),
- "a"-diode's ideality constant,
- "k"-Boltzan's constant,
- "T_{cK}"-Temperature of cell

The resultant current of the solar cell so calculated is given by subtracting normal diode current I_D from photo current I_L, which is illustrated as below.

$$I = I_L - I_D \quad (2)$$

Moreover, below equation shows the work done by Gowy Manning [4] which represents the simplified model.

$$I_d = I_L - I_o[\mathrm{e}^{\frac{(v+IR)q}{aktck}} - 1] \quad (3)$$

Hence, the ideal solar cell can be represented by anti-parallel connection of current source along with diode. The effects of series and shunt resistances are included for the improvement of PV cell model.

III. DESIGNING A PROPOUNDED PV-SYSTEM

For the propounded PV-module which is attached with the grid having various components such as PV-cell, capacitor and inductor are selected and assembled according to the requirements[5].

Parameters for Photovoltaic Array- In the propound system, the solar panel is used which provides the highest efficiency, robust, reliable and also provides 50% extra power per unit area. Here, the selection of 20parallel and 6 series panels are there for PV-Array [6]. Mostly, there is occurrence of 85% of maximum power at open circuit voltage and the maximum power at short circuit current is also 85%

The parameters so used for PV cell at 1000W/square metre and 25^0C are:

Open Circuit voltage = 64.2
Short Circuit Current = 5.96
Max Power voltage (V) = 54.7
Max Power current (A) = 5.58
Maximum Power (W) = 305.226
Maximum power output of PV-Array = 36.6KW

Hence, the fundamental equation above does not entitled the I-V attribute of the solar panel. Moreover we can also say that the panel comprises of various resistances and cells connected to panel. Therefore by surveying of the attribute at the ends of the PV module need the incorporation of more criteria, which is further represented in equation (4).

$$I_d = I_L - I_o[\mathrm{e}^{\frac{(v+IR)q}{aktck}} - 1] - \frac{(\mathrm{V} + IR)}{R_{sh}} \quad (4)$$

Therefore, equation above entitled the generated current of the output side of the cell depends on the voltage of PV module, irradiance due to sun on PV module, speed of the wind, and ambient temperature.

IV. EQUATIONS SHOWING THE SOLAR CELL CHARACTERISTICS

The solar cell edifice is indistinguishable with the diode. Moreover, its attribute must be homogeneous for the exponential attribute of the semiconductor. Considering, the panel which is made up of the set of cells, which accord current to cell. The model so obtained is based on the photocurrent and diode's inverse current at the saturated region.

Basically this division represents the most fascinating equations which flourish the sun cell module. Moreover this, the current so develop is photoelectric which depends on temperature variation and irradiation existing.

$$I_L = I_L(T_1) + \mathrm{K}_0(\mathrm{T} - \mathrm{T}_1) \quad (5)$$

Knowing that,

$$I_L(T_1) = I_{SC}(T_{1/nom})\frac{G}{G_{nom}} \quad (6)$$

$$K_0 = \frac{I_{SC}(T_2) - I_{SC}(T_1)}{T_2 - T_1} \quad (7)$$

Moreover, the current of the diode which is inversely saturated is considered in equations (8) and (9):

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$$I_0 = I_0(T_1)(\frac{T}{T_1})^{\frac{3}{n}} e^{\frac{qV_q(T_1)}{nk(\frac{1}{T}-\frac{1}{T_1})}} \quad (8)$$

$$I_0(T_1) = \frac{I_{sc}(T_1)}{(e^{\frac{qVoc(T_1)}{nk(T_1)}} -1)} \quad (9)$$

The ideality of diode or quality factor Value is considered 1.2 - 1.62 approx.

The band gap voltage taken is equal to 1.12, for silicon, although the band gap may vary depending on the choice of material type. In case of GaAs the band gap is 1.42, the band gap 1.5 is taken for CdTe and 1.75 band gap is considered for amorphous silicon.

Considering Temperature coefficient of I_{SC}

$$a = \frac{I_{SC2} - I_{SC1}}{I_{SC}(\frac{1}{T_2 - T_1})} \quad (10)$$

$$K_0 = \frac{I_{SC}(T_2) - I_{SC}(T_1)}{T_2 - T_1} \quad (11)$$

Photoelectric current (I_L & I_{Ph}) is equal

$$I_L = I_{SC}(T_1).Suns + k_0(TaK - T_1) \quad (12)$$

$$I_L = I_{SCT_1}.Suns(1 + a(TaK - TrK)) \quad (13)$$

Finally the Ia current so obtained

$$I_a = I_a - \frac{I_a - I_{ph} + I_r(e^{\frac{V_C + I_a R_a}{VtT_a}} - 1)}{\frac{I_r R_s (e^{\frac{VC+IARA}{VtTa}} - 1)}{Vt\_Ta} + 1} \quad (14)$$

V. MATLAB SIMULATION MODEL

By using the above equations the solar cell so designed is shown given below-

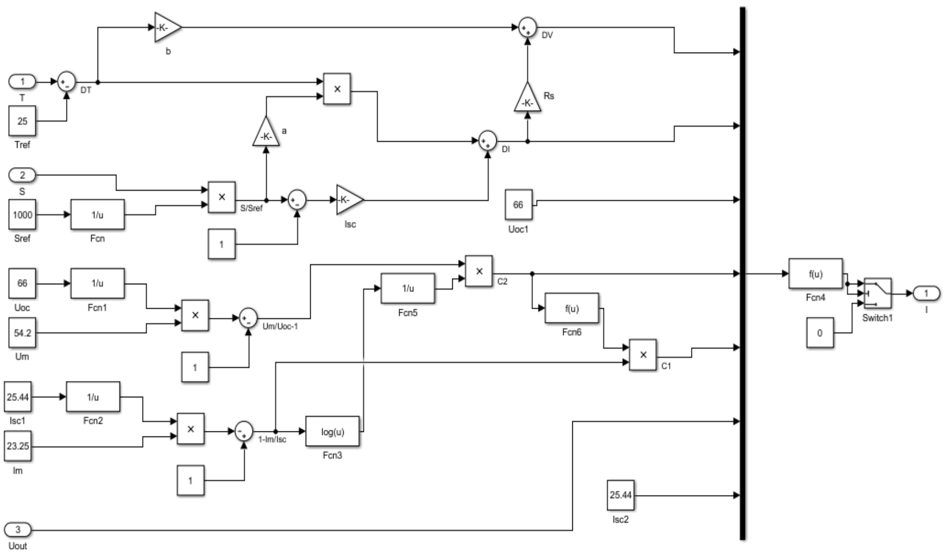

Fig1- MATLAB simulation model

VI. MPPT WITH PERTURB AND OBSERVE METHOD

Now-a-days many papers are showing concern regarding the maximum power point tracking (MPPT) of non-conventional assets from the last ten years. Mostly a lot of them find a new approach aiming at getting the peak value of power from a photovoltaic (PV) any type of climatic conditions, for instance irradiance and temperature, unknowingly of the exact conditions of the PV-panel. The most effective and useful method distributed into two different approaches, namely incremental conductance and the other one is perturb & observe techniques. The perturb and observe is mostly used because it is a simple technique. In spite of its maximum use it has many drawback, its main drawbacks are in the stationary conditions there is a waste of energy, when there is deviation in working point towards the MPP, moreover if there is stiff variation in solar irradiance then it exhibits poor dynamic performances

6.1. WORKING OF P&O

During this process, the resultant values are calculated and hence the average input power of the converter is measured. Thus the calculated value is put in comparison with the calculated value of output power previously. Perturbation supplies the range of operating voltage of the module up to the point when it reaches to the global MPP. As soon as the point of operation is reached towards the right side of the MPP, there is decrement/increment in the voltage that causes increase/decreases in the power. On the contrary, as soon as the point of operation reaches the left side of the MPP, there is decrement/increment in the voltage decreases/increases the power. Perturbation is selected in such a way that if there is increase in the power due to a voltage perturbation, the similar perturbation is kept so longer until it attained the global MPP. If there is decrease in the power due to a voltage perturbation, then there is a reversal in the polarity of the perturbation. The duty cycle of the converter changes accordingly with the results so obtained which causes the steady-state operation.

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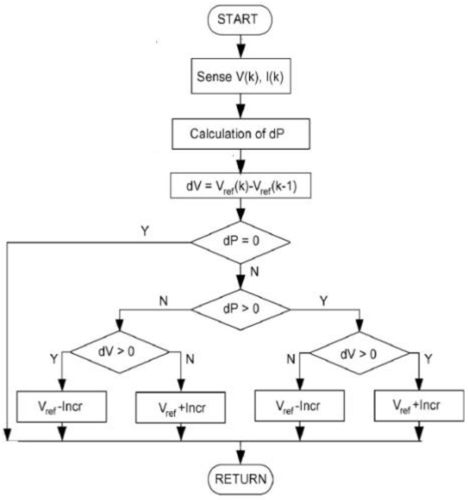

Fig2- Flowchart of P&O method

VII. SIMULINK MODEL OF PV SYSTEM

The Simulink model thus enacted to single phase battery attached PV-system with MPPT operating the MPPT at variable temperature ranges, which is illustrated in the figure. In this model the block of MPPT is presented by perturb and observe algorithm. Hence the solar panel so used is shown by using block including the series connection of controlled current source to that of resistance. The generator which generates the gating signal is a single unit is known as MPPT. The 'Generator I' generates the photo current which act as an input to the single cell diode model. The boost converter is also one of the important element connect in this model.

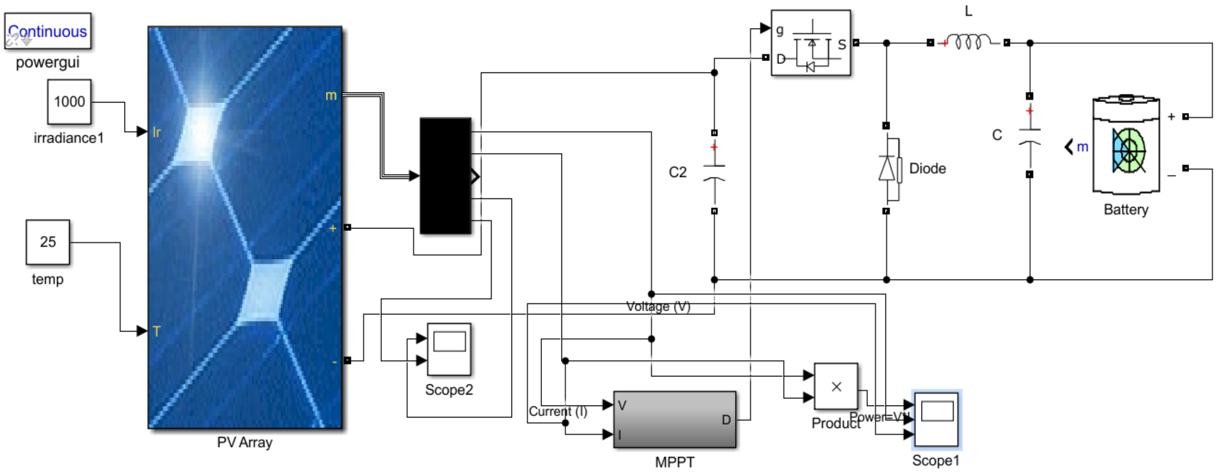

Fig3- Simulink Model of PV cell

VIII. RESULTS REGARDING SIMULATION

The simulated results of PV-system is flourished under the circumstances like variation in the irradiation and also the variation in temperature is illustrated in the below illustration. Although these circumstances are considered, but still the voltage is retained constant which give the result of the effectiveness in the presented controllers[2].

Illustration.1- Irradiation variation- If there is a condition of variation in irradiation, the PV-module which is connected to the grid executed for linear load is shown in Fig.4. For the variation in irradiation goes from 1000 W/m² to 800 W/m² it will take time equal to 0.2 sec and for change from 800 W/m² to 1000 W/ m² time taken is 0.3 sec. Variation in irradiation only changes the PV-Current which in turn changes the power of PV cell from 35KW to 28.9KW then again reaches to 35KW in the specified time and the attribute of irradiation where the power is maximum. The waveforms of voltage and currents so obtained during this instant are under the harmonic limitations.

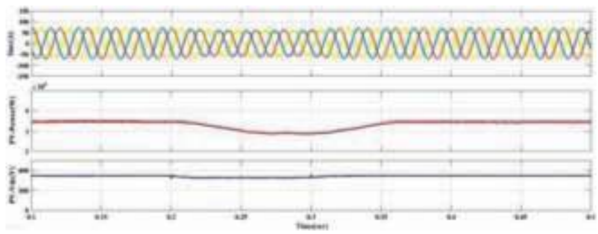

Fig.4- Outcomes of irradiation variation.

Illustration.2- Temperature variation- If there is condition of temperature variation, the PV-module which is connected to the grid executed under linear load with the temperature variation is illustrated in Fig. 5. The variation in temperature from 25°C to 50°C the time taken is 0.2 sec and when there is 0.3 sec, the temperature falls from 50°C to 25°C. The variation in the temperature on DC voltage output changes the power of PV cell from 35KW to 31.2 KW then again to 35KW in specified time and attribute to the temperature at that peak power. The waveforms of voltage and current so obtained during this instant are under the harmonic limitations.

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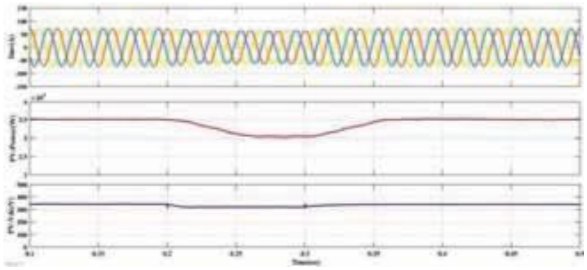

Fig.5- Outcomes of temperature variation.

IX. CONCLUSION

The model developed, with the main electrical parameters, are valid to measure I-V characteristics and hence in this the work is undertaken with few parameters which is taken as input for the demonstration of graph and numerically operate the solar model. The future objective is to flourish a full model which attribute the electrical etiquette to the PV module which also evolved, commence of these models. And the MPPT technique so used is the best and reliable technique for getting optimum energy.

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