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SIMULATING AND ANALYSIS OF DISTRIBUTED PV GENERATION IN LOW POWER DISTRIBUTION NETWORK

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ABSTRACT: Recently most of the researches focus on solar energy. Many techniques are their to convert solar energy in to more efficient electrical energy. The interface of power electronic devices in almost all the fields have made more sophistication in industries with loads that require the most efficient and accurate power. This paper focuses on simple and efficient modeling approaches that are suitable for long term and large photovoltaic system analyses. This paper deals mainly with a simplified photovoltaic cell model with interleaved fly back module integrated converter(MIC) for grid tied system. Simulation is carried out with temperature and solar irradiance as inputs to the photovoltaic cell. Mat lab simulation technique is used to solve the circuit.

Keywords: Solar energy, Photovoltaic (PV), Maximum power point tracking(MPPT), Module integrated converter(MIC).

I. INTRODUCTION

Photovoltaic panels are used to convert solar energy into electrical power. The solar photovoltaic panel output characteristics are dependent on operational conditions such as temperature and irradiance level. Photovoltaic power systems are becoming increasingly important with wide acceptance and integration of solar energy in modern electric grids. In recent years, PV power systems have drawn significant research attention, wherein modeling and computer simulation are necessary to analyze the system operation and interaction with utility grids. Over past decade various simulation methods have been proposed with significant effort focused on photovoltaic modeling and parameterization. This proposed parameterization is complex and PV models derived from this require an iterative solver for simulation implementation. This results in high complexity and impossible to simulate large scale PV power systems using low cost platforms. Tremendous efforts focus on MATLAB-SIMULINK based simulation platforms. These are generally based on specific applications and platforms therefore a generalized approach is needed for the efficient modeling and simulation which is applicable to long term operation of various photovoltaic power systems.

Generally typical photovoltaic power systems are of two types, they are utility interface is achieved using two converters and intermediate link and single converter without intermediate link.

II. SIMULATION MODELS

A simplified single diode photovoltaic modeling approach is introduced to parameterization of PV cell models. The model implementation is provided with power interface topologies with intermediate DC link used as string inverts and single stage DC to AC conversion proposed as module integrated converter (MIC). Fig1. shows the equivalent circuit for the ideal single diode PV cell model.

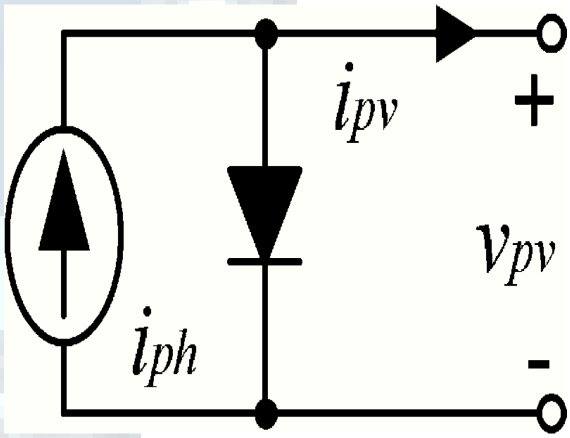

Fig.1 Equivalent circuit for single diode PV cell model .

The ideal single-diode model which is shown in Fig.1 was proposed to represent PV outputs for crystalline-based solar cells. The simplified model shows computational efficiency but provides fewer tuning parameters in comparison with the standard single-diode model. The model parameters should be properly identified, and the modeling accuracy should be evaluated carefully before it is integrated into system simulation. The PV manufactures provide the values of open circuit voltage, short circuit current and the maximum power point at standard test condition. According to the equivalent circuit of single diode PV cell model the value of photon current is equal to the short circuit current at standard test condition. When the solar cell is open circuited the output current of a PV cell is zero. Therefore the I-V characteristics of PV cell model can be calculated at standard test condition. The entire PV model simulation can be expressed as generalized flowchart shown in fig.2.

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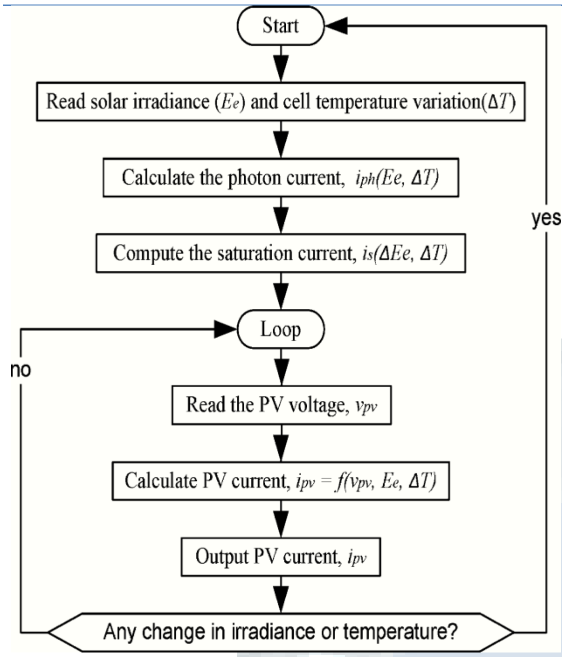

Fig.2 Flowchart of the PV model simulation.

A. INTERFACE WITH INTERMEDIATE DC LINK

The PV model simulation is consists of PV array, MPPT power interface and DC link. The dc/dc converter in the circuit works in the continuous conduction mode. The entire block diagram of PV array and power inter face is as shown in fig.3.

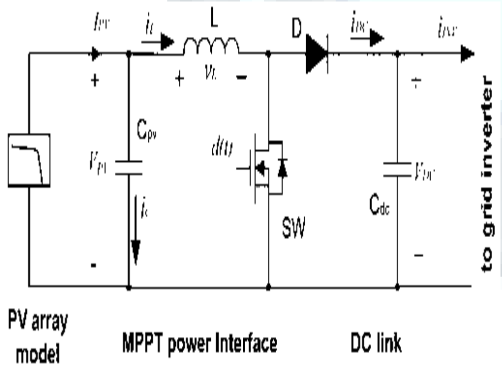

Fig.3 circuit schematics showing the combination of the PV array and dc/dc power interface.

This feature is important to simulate a large power system with multiple inverter based generators. In this the dc/dc converter works in continuous conduction mode (CCM), the averaged model can be derived as follows

$$V_{PV} = 1/C_{PV} \int (I_{PV} - i_l)\, dt \quad (1)$$

$$i_L = 1/L \int [V_{PV} - (1- d) V_{dc}]\, dt \quad (2)$$

$$V_{dc} = 1/C_{dc} \int ((1- d)\, i_L - i_{NV})\, dt \quad (3)$$

From the following expressions the averaged model can be constructed as shown in fig.4. Where the input is the injection current to the grid inverter i_{1NV} , the control variable is the duty cycle d , and the state variable includes V_{dc} , V_{PV} and i_L.

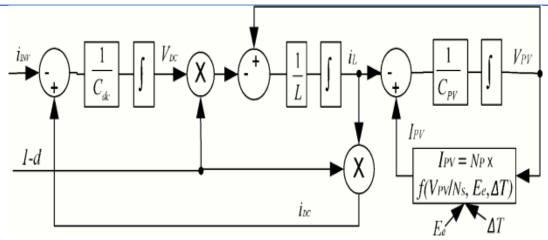

Fig.4 Averaged model in CCM combining the PV array and the boost converter power interface.

B.INTERFACE WITHOUT INTERMEDIATE DC LINK

String inverters show significant generation degradation that result from PV module mismatch and partial shading. The emerging solution is the MIC, which is also called the micro inverter, to eliminate the power loss that results from inconsistent impacts. A specific MIC, which is shown in fig.5. and adopting the interleaved fly back topology, is considered in this study. The topology offers the advantages of high efficiency, reliability, power sharing, galvanic isolation, and reduced PV voltage ripple. Therein, all the details about the converter operation can be found.

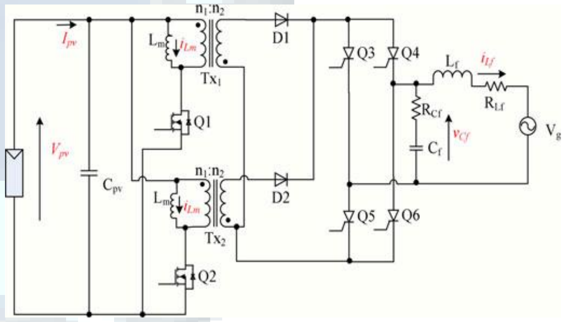

Fig.5 Topology of the interleaved flyback MIC for solar grid tied systems.

The simulation model of the MIC is developed by the average technique. In this a simplified simulation model is constructed to evaluate the dynamic model of MPPT. The averaged simulation model is shown in fig.6.

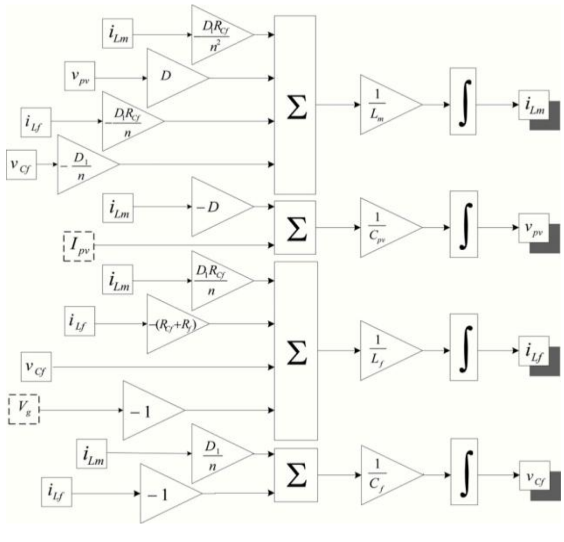

Fig.6 Averaged simulation model of the flyback based MIC with current unfloding circuit

C. SIMULATION MODEL OF MPPT

The voltage of the optimal operating point (V_{oop}) represents the MPP. In this paper it is estimated as

$$V_{oop}(\Delta E_e , \Delta T) = V_{MPP}(1+\beta_T\Delta T)(1+\gamma_E\Delta E_e) \quad (4)$$

where β_T and γ_E are the temperature and irradiance of PV voltage. ΔE_e is the irradiance difference from standard test condition. One of the commonly used MPPT algorithms is the perturbation and observation (P&O) method, which applies two parameters, the perturbation time interval ΔT_{MPPT} and perturbation amplitude ΔV. Thus, the MPP tracking dynamics are implemented by a slew-rate limiter, as expressed in (5), shown below, which defines the maximum rate of the setpoint change

$$SR= \Delta V/ \Delta T_{MPPT} \quad (5)$$

As a result, the MPPT operation can be simplified as the diagram shown in Fig. 7, where the optimal operating point is calculated by (4), and the slew-rate limiter mimics the MPP tracking dynamics.

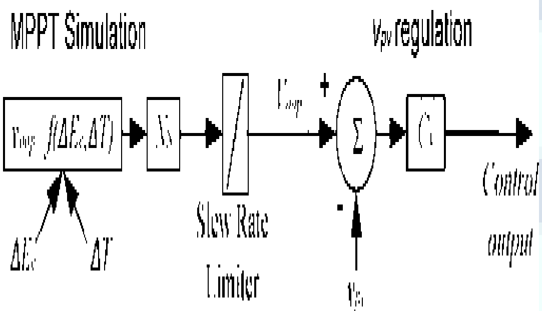

Fig.7 Simulation implementation of MPPT using slew rate limiter.

III. SIMULATION RESULTS

The initial inputs of the PV array are temperature and solar irradiance the simulation outputs are as shown below. The input temperature for the PV array is taken as constant and the simulated result is shown in fig.8.

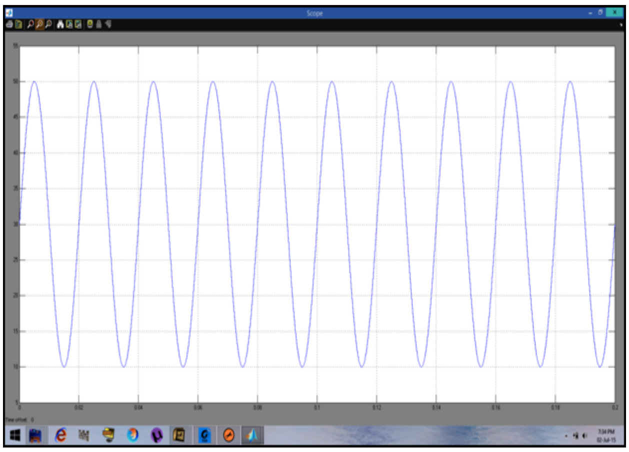

Fig.8 Input temperature for PV array.

The input solar irradiance for PV array is as shown in fig.9.

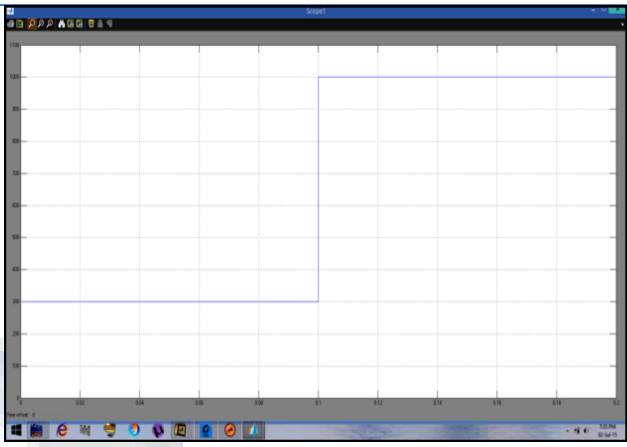

Fig.9 solar irradiance.

As the inputs are given to the PV array associated with PV cell the solar irradiance shows an impact on the voltage of the optimal operating point for the system. The change of voltage of the optimal operating point of the system is shown in fig.10.

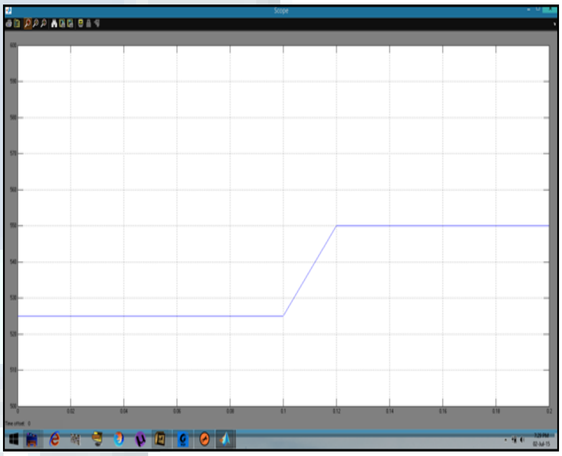

Fig.10 Impact of solar irradiance on voltage.

Based on the inputs and the impact of input on the voltage the proposed module integrated converter(MIC) generated the simulated waveforms of current and power at the PV cell. The AC output current is measured at the inductor. The simulated results are shown in fig.11, fig.12, fig.13.

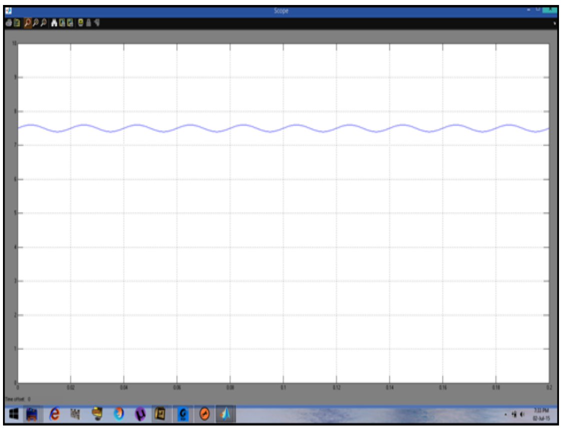

Fig.11 PV current.

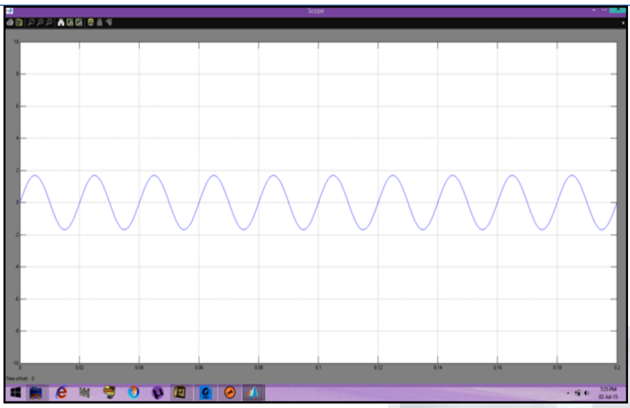

Fig.12 AC output power.

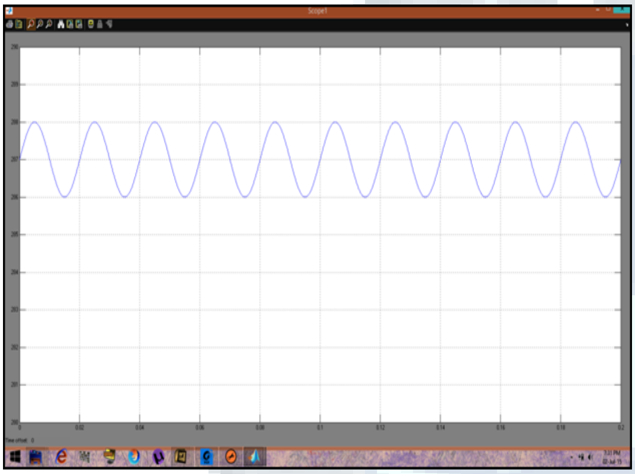

Fig.13 PV power.

IV. CONCLUSION

This paper has presented a general approach to the modeling and simulating PV power system. A simplified PV model is developed by the given information in data sheets. Mostly the PV power systems are grid tied the modeling process focuses on two common power interfaces that include two stage power conversion with intermediate DC link and single stage power conversion without intermediate DC link. The MIC called module integrated converter or microinverter is included in simulation. Due to the presence of MIC the proposed model works with more speed when compared with conventional physical model.

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