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Development of a MATLAB/SIMULINK Model of a Control System for Integration of a Utility Grid and a PV System

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ABSTRACT-During the last decade, the renewable power sources such as photovoltaic (PV) modules are growing fast as an effective and cheap energy source. It is a crucial issue to integrate PV into the grid. In this paper, a control model for integration of PV system into the grid and the effectiveness of the PI controller in the system under different levels of solar irradiation are presented. An MPPT module with PI control developed in this work that is felicitous for power applications program; however, the problem of integration of PV is that it relies heavily on weather conditions. So, there is a necessity for developing control techniques for grid integration PV system including a method for voltage and current control that stabilises the voltage and current. An MPPT algorithm using DC/DC converter (Boost converter) is applied to make PV arrays to work at maximum power point. Then, the system behaviour and performance are studied. The system stability is also considered when there is a change in solar irradiation or a fault in the system. The simulation results of MATLAB/SIMULINK address that the proposed PI controller has a good performance.

Keywords: MATLAB/SIMULINK, Photovoltaic (PV, Maximum power point tracking (MPPT), Boost converter DC/DC, PI controller, the utility grid.

1. INTRODUCTION

Nowadays, PV technology provides an extra focus on the advantages of sun-powered vitality being perfect, abundant, environment-friendly, and inexhaustible. The PV framework can be considered as the proficient system to give the power to some remote off-lattice areas furthermore it can be financially savvy when contrasted with the expense of running electrical cables from the current matrix. Actually, there are a lot of effects that almost change the output power of the PV system, such as ambient temperature, shading, and relative humidity. Because of the environmental factors and change of solar irradiation , the PV system output power is a stochastic system [1].

Recently, Solar PV is an essential technique of different sustainable power sources. It is widely used all over the world because it is cheap and simple.

Solar energy is assumed to play an important part in the coming days, especially in this period most of the developing countries in the world focus in this area. So the generating of electric power by using solar cells is an effective technique nowadays. In [2], the local voltage control strategies applied to control PV storage systems.

The scheme depends on inserting a voltage control, to self-consumption strategies using a combination of voltage-dependent battery charging.

The module of PV output efficiency in recent years has been increased about 24 to 30%, so the PV technology is growing fast, we believe that PV definitely will have the perfect position in the incoming future [4]. In that paper, they give some ideas about a single-phase five-level photovoltaic (PV) inverter scheme for PV systems connected to the grid with a new pulse-width-modulated (PWM) control design.

In [5], the proposed algorithms are verified by the simulator and then it is synthesised in the form and are compared with practical results that with the single-phase three-level inverter connected to the network of conventional PWM. The paper presented a model of photovoltaic suitable for use, the ability to upgrade various designs. Dealing in later with a sound analytical PV cell model, and work in this paper modelling clearly appears under SIMULINK.

The excitement of the model of the three entrances to contain the radiation, temperature, voltage design. Who is running simulations and the results in terms of peak power and analyse the current [6]. This paper has been referenced in the prediction model for PV out of the current, and this model depends on the cascade-forward, back propagation artificial neural network (CFNN) with two inputs and one output.

The experimental data used for the PV system 1.4 kW for two years in this search, for this purpose an experimental database of the solar power output, module temperature, air and solar irradiance data has been used. Ref [7] address data from Building in Malaysia that is Green Energy Office.

That paper proposed a utility grid linked multi-string photovoltaic (PV) framework with a three level voltage source converter using twofold shut circle control strategy.The outside DC voltage control circuit controls the DC transport voltage while the inward current control circuit synchronises the yield current with the network

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voltage, in this way ensuring power component equivalent to one. In [8], the given scheme, LLC resonant DC/DC converts is applied to get the maximum power and boost the PV array voltage.
The evolution of the grid linked Large scale power plants in light of the fact that the expanding entrance of renewable vitality. The control technique strategy can do the PQC, as well as it can remunerate the receptive force requested by a voltage drop/swell for grid adjustment. The control procedure does not require any outside equipment alteration when contrasted and the utilisation of traditional current control [9].
Development in the efficiency of photovoltaic cells and low price make them widely accepted and concentration in all of the world and not to rely on non-renewable energy sources, the most important advantages we have got electrical energy through clean renewable energy. The power plants these days are required to expand their vitality generation, needing suitable control methodologies to support take care of the issues identified with the fractional shading wonders and the distinctive introduction of the PV modules toward the sun [10].
The control technique is to integrate the distributed generation (DG) resources to the electrical power network. The suggested control, it can be compensated for active, reactive, and harmonic load current components during connection of DG links to the grid.
The effectivity of the control capability in circulated engendering application is exhibited be including the greatest may from the DG to the utility grid, the expanded force specialists of the utility grid, and diminished sum consonant twisting of grid current in reenactment and trial occasion under unfaltering state and element working conditions. The dependability of the utility grid when the PV plant is associated with the utility grid, the power quality, and the execution of assurance and lattice synchronisation capacities [11].

2. MODELLING A PV ARRAY CONNECTED TO THE UTILITY GRID

It is a detailed model for a group of 100 kW connected to the 25 KV through a boost DC-DC converter. And it is performed Maximum Power Point Tracking (MPPT) in batch conversion by SIMULINK model using the P controller.
Is the average model of network connected PV, a group of 200 kW connected to 25 KV network via two DC-DC converters boosts unit my control. It is implemented controller maximum power point tracking at the "confusion and control" technology through MATLAB function [3].
The Solar PV system shape consists of the demanded some of the PV cells, such as the photovoltaic has been mentioned, linked in parallel or in series to produce the wanted output voltage.
The essential neutralisation of the semiconductors theory, which mathematically define the I-V relationship of the model photovoltaic.

$$I = I_{pv,cell} - I_{0,cell}\left[exp\left(\frac{qV}{\alpha KT}\right) - 1\right] \quad (2.1)$$

The simple PV cell does not express the I–V relationship of an actual PV array. Cells linked in parallel rise the current and cells linked in series produce higher output voltages.
The actual arrays are built by a lot of linked PV cells and the notice for the characteristics of the ends of the photovoltaic array needs the implying of such parameters to the main equation.

$$I= I_{PV}\text{-}I_0\left[exp\left(\frac{V+R_S I}{V_t\alpha}\right) - 1\right] - 1\,\frac{V+R_S I}{R_P} \quad (2.2)$$

We assume I_{sc} and I_{PV} ordinarily used in the PV device modelling as in working designs the parallel resistance is high but series resistance is low.

The diode saturation current is presented by:

$$I_0 = \frac{I_{SC,n}+K_{I\,\Delta_T}}{exp\left(\frac{V_{OC,n}+K_{V\,\Delta_T}}{\alpha V_t}\right)-1} \quad (2.3)$$

From the equation, the model is simplified and the model error is equal to zero near of the open-circuit voltages, and as the results, at other regions of the I–V plot:

$$I_{PV}= \left(I_{PV,n} + K_{I\,\Delta_T}\right)\frac{G}{G_n} \quad (2.4)$$

The R_S and R_P the relationship is an unknown of (2.2) may be calculated by setting $p_{max,m}= p_{max,e}$ and solving the fulfilment equation for R_S, as given:

$$P_{\ max,m} = V_{mp}\left\{\begin{matrix} I_{PV} - I_0\left[exp\left(\frac{q}{KT}\,\frac{V_{mp}+R_S\,I_{mp}}{\alpha N_S}\right) - 1\right] \\ -\frac{V_{mp}+R_S\,I_{mp}}{R_P}\end{matrix}\right\} = P_{max,e} \quad (2.5)$$

$$R_P=\frac{V_{mp}+I_{mp}\,R_S}{\left\{V_{mp}\,I_{PV}-V_{mp}I_0\,exp\left[\frac{\left(V_{mp}+R_S\,I_{mp}\right)}{N_S\alpha}\,\frac{q}{KT}\right]+V_{mp}I_0-P_{max,e}\right\}} \quad (2.6)$$

The means ofEquation 2.6 that for any value of R_P there will be a value Of R_S that makes the mathematical I–V curve cross the experimental (I_{mp} , V_{mp} ,) point.

The aim is to find the value of R_P and R_S for the best model solution.

$$I_{PV,n} = \frac{R_P + R_S}{R_P} I_{SC,n} \tag{2.7}$$

The initial conditions can be set as:

$$R_S = 0\,,\ R_{P,min} = \frac{V_{mp}}{I_{sc,n\_} - I_{mp}} - \frac{V_{oc,n} - V_{mp}}{I_{mp}} \tag{2.8}$$

From the equation 1.8, the minimum value of R_P Is given by relationship between the maximum-power points and the short circuit [1].

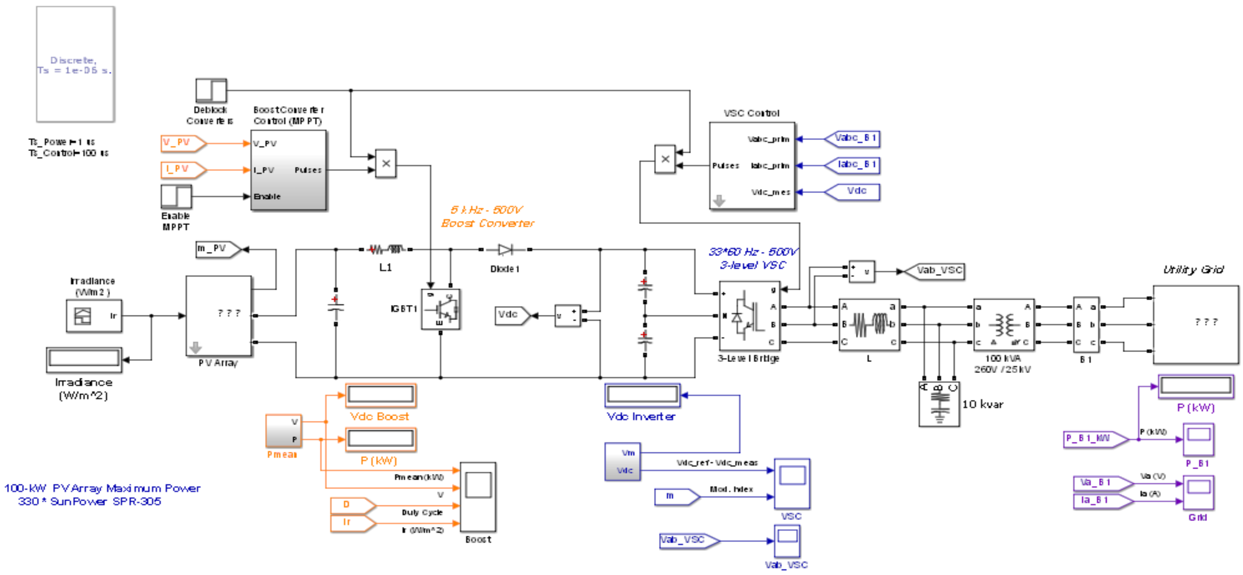

Fig. 2.1 grid connected PV farm

3. CONTROL STRATEGY OF GRID-CONNECTED PV SYSTEM

For the purpose of utility grid-connected PV system controller, MPPT scheme is applied. The boost converter boosts DC voltage from 273.5 V to 500V. This circuit utilises an MPPT framework which naturally changes the duty cycle to get the required voltage to obtain the maximum power.

In this paper, PI controller is used with a model of PV gives a good idea of the suitable control performance of any real system with change time during the day and can be used to analyse the performance of the PV generation system. The control is developed and tested in Mat lab/Simulink platform.

The PI controller improves the response of the system exposed to a change in irradiation, and the power not decreases to zero value.

3.1 MPPT Control Algorithm

The MPPT algorithms are required because PV arrays have a relationship between Current and voltage is nonlinear and there is a singular point where it provides the maximum power. This point relies on the temperature of the panels and on the irradiance terms. Both terms change during the day and are also different rely on the season of the year. Moreover, irradiation changes fast due to changing atmospheric terms such as cloudy terms. It is necessary to follow the MPP accurately under all reasonable conditions, therefore that the maximum available power is always obtained.

MPPT by incremental conductance method is realised. The problem by simulating the controller with various combinations of I and P simultaneously and watching the output for the key response parameters of interest.

These key responses are maximum overshoot that should be low, rise time that should be low, and also the settling time that should be low. The combinations of P and I give the optimum output response. The increased time, steady state error, settling time and overshoot, these four parameters will tell us that how to change the parameters of the controller. PI controller has the transfer function:

$$C(s) = K_P + \frac{K_I}{s} \tag{3.1}$$

If the system is nonlinear, then the tuning problem will be difficult as the PI parameter values will need some adjustment depending on the operating condition under which system is running.

4. SIMULATION RESULTS

The PI controller of integration of PV system into a grid has been modelled and simulated by MATLAB/SIMULINK using the power systems block set.

The used simulation parameters of the utility grid interconnected PV circuit and MPPT are shown in Table 1.

TABLE-4.1 Parameters of the System

Parameter	Value	Parameter	Value
No. of cell	96	R_p	999.51
V_{oc}	64	R_l	5 Ω
I_{sc}	5.96	L	5 mH
V_{mp}	54.7	C_3	1200 MF
I_{mp}	5.58	K_p	2
R	0.038	K_i	10

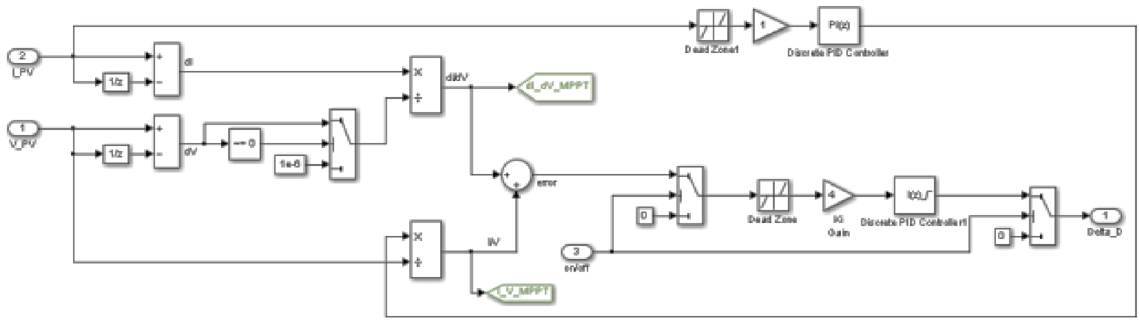

Fig. 4.1 PI Controller MPPT

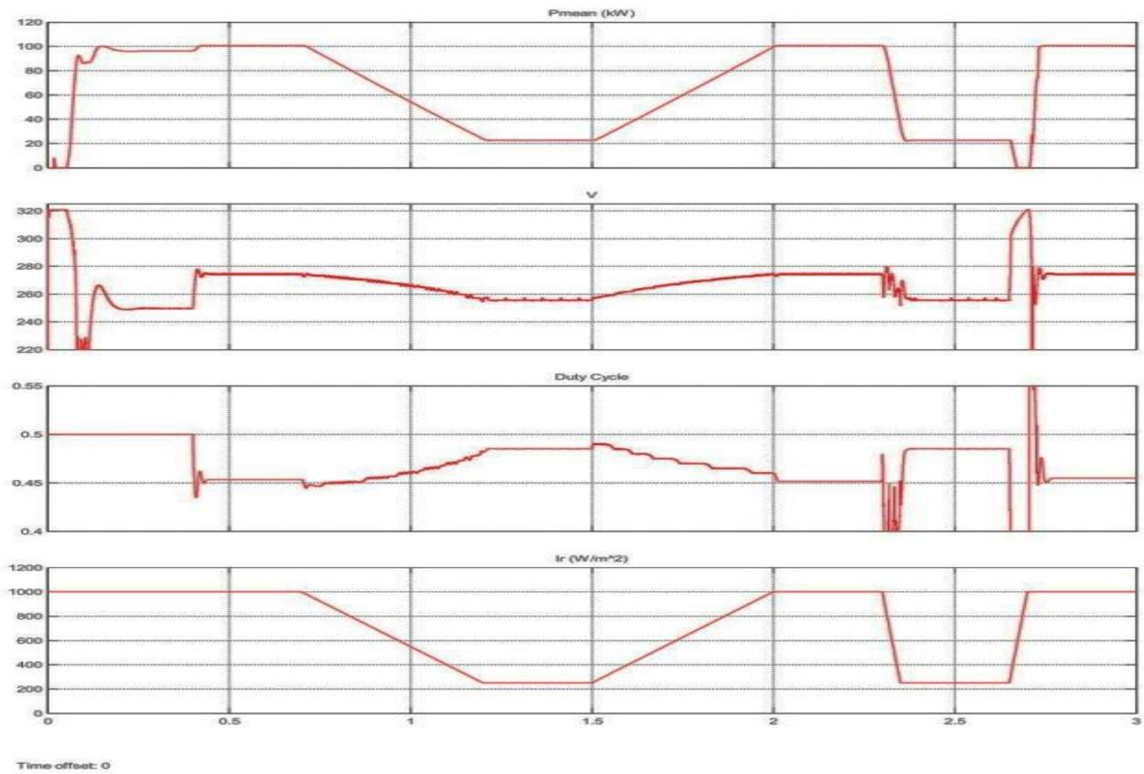

Fig. 4.2 Result Without PI Controller

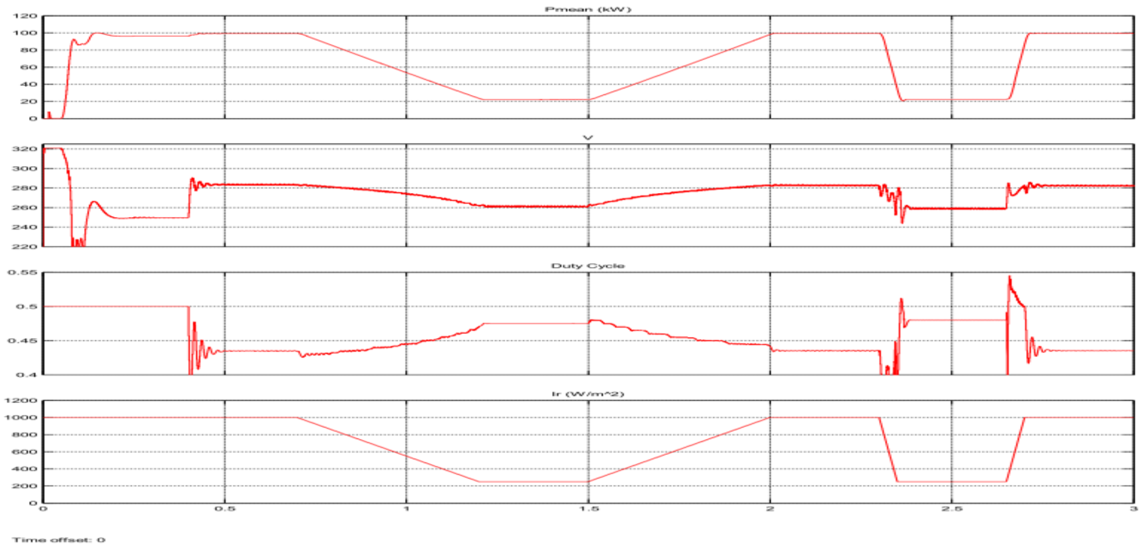

Fig. 4.3 Result of PI Controller

CONCLUSION

The scope of this paper is to model a control of utility grid for the integration of PV system into a grid by using MATLAB/Simulation. This model is based on the basic circuit of the solar cell PV system integrated into the grid the effects of parameters such as solar radiation surround. Environmental and physical parameters such as the cell temperature and solar radiation. The boost DC/DC converter connected to PV system and the controller system is based on the maximum power point tracking (MPPT) with a PI controller ensure the maximum power in case of fluctuation in the weather, which is then integrated into the AC utility grid by DC/AC inverter.

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