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Modelling And Design of Single Phase Solar Photovoltaic Roof-Top System

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***Abstract*—This paper deals with Modelling And Design of Single Phase Solar Photovoltaic Roof-Top System. In this paper grid synchronization technique is developed which deliver power to the grid at different load condition at unity power factor, As in the modeling and designing of photovoltaic (PV) and photovoltaic power generation with their maximum-power-point tracking (MPPT) methods. For maximum power tracing incremental conductance (INC) control technique is used. To convert solar DC power into AC single phase voltage source inverter is used in synchronized with grid by hysteresis current loop control. The effectiveness of the proposed power system is confirmed via extensive study using MATLAB-Simulink software. The obtained results are promising**

Keywords*— *Power system, MPPT, Photovoltaic (PV), sustainable energy (SE), utility grid and Voltage Source Inverter (VSI)

I. INTRODUCTION

In this modern world, energy has become an integral part of our life. This energy come from normally the energy we used in the form of diesel, petrol, coal, liquid petroleum gas (LPG), compressed natural gas (CNG) and electricity. The electricity mostly derived from fossil fuel like coal, diesel etc. These energy sources are not only limited in nature but also its responsible for environment pollution and rising in prices. Rising in prices causes the worldwide economic instability. [1-3]. To overcome these problems attention toward new trend of power generation using sustainable energy (SE) such as Solar Energy, Wind Energy, Bio Mass energy, geothermal energy and Tidal energy. These resources can be naturally replenished and never go out of stock. [4-5].

Photovoltaic (PV) systems are widely applied to off-grid generation applications such as traffic warning lights, telecommunications, and security systems [6], when the electricity demand exceeds the supply of PV system, wind system, biomass or conventional electric generator or utility grid can be added with PV system to create a hybrid system.[7], honce, a hybrid generation system can offer higher reliability to maintain continuous power output than any other individual power generation systems [8-10], also hybrid system improves the load factor and reduces the replacement and maintenance cost [11] Hybrid power generation system can be installed within short span of time with high reliability and sustainability. The designing and modelling of hybrid power system requires optimum selection of components with efficient control techniques for 24 hour power at an affordable price [12-14].

In the proposed research work grid connected solar power generation system is developed in which sources of power generation is sustainable energy sources which is solar energy.

To increase the efficiency of PV array maximum power should be extracted from it. And Perturb and Observe is used to extract maximum power from solar energy through the duty cycle control of Boost converter. [15-18]. Varying duty cycle matching the source impedance and load impedance thus maximum power is transform from source to load [19-20].

This paper presents a sustainable energy based grid connected solar power system to extract maximum power Perturb and Observe control is implement on boost converter and to synchronized the ac grid three phase voltage source inverter control is done by current loop hysteresis controller this control scheme for VSI to regulate the output voltage and frequency under different load conditions such as balanced/ unbalanced linear and non-linear loads. The paper is organized as follows; section II gives the system configuration, section III presents model of sustainable energy based grid connected solar power system, section IV gives the controlling of proposed system, section V performance evaluation using MATLAB 2015a are given and section VII provides conclusions of the work.

II. SYSTEM CONFIGURATION

Fig. 1 shows the proposed system configuration of Single Phase Solar Photovoltaic Roof-Top System. It consists of insulated- gate bipolar transistor (IGBT) based boost converter in PV side. While in ac side three phases VSI is developed by using IGBT switch this inverter is synchronized with grid voltage and frequency by using hysteresis current loop.

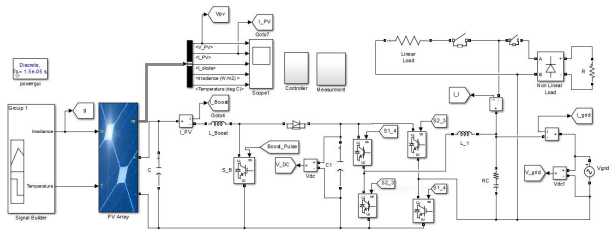

Fig.1. Proposed Single Phase Solar Photovoltaic Roof-Top System

III. MODELLING OF GRID CONNECTED PV SYSTEM

This section of paper described the modeling and designing of utilizing sustainable energy-based power generating station capacity.

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A. *Model of Solar Photovoltaic Generator*

Crystalline silicon is generally used to manufacture the PV cell and PV cell connected in series to construct PV module. And it's performance is highly influenced by weather condition such as solar irradiation and cell temperature. PV voltage and current are main parameter. PV current is almost directly proposal to the solar irradiation form Eq. (1)[21] and PV voltage increasing slowly whenever solar irradiation is increases, but increasing in temperatures decreases the PV module voltage. Fig. 2 shows the equivalent circuit of PV module. Current equation of PV module are given as,

The formula to calculate the electric energy generated as output of a solar photovoltaic system is given in Eq. (2)

$$I_{Li} = G(t)\left[I_{sc} + \beta_{i(\theta - \theta_r)} \right] \quad (1)$$

$$P_{gpv} = N_s N_p P_m \eta_{mpp} \eta_{oth} \quad (2)$$

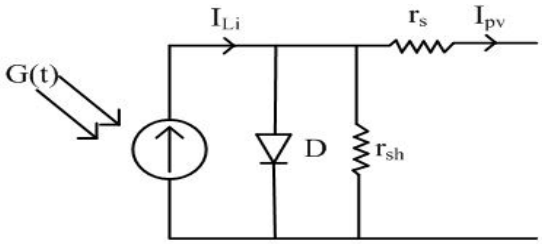

Fig. 2 The equivalent circuit of PV module

B. *Design of PV array*

Power generated by solar PV system is P_{gpv}=2 kW, Single PV module power P_m=250W, MPPT efficiency η_{mppt} =95% and efficiency due to other factor η_{oth} = 98% there for No. of series and parallel PV module can estimate with consideration voltage level. Np= 1 and Ns = 8.

IV. CONTROLLING OF PROPOSED SYSTEM

A prototype of Single Phase Solar Photovoltaic Roof-Top System is developed in matlab Simulink. Here DC-DC boost converter is used to extract maximum power and P and O method is used to extract maximum power and to operate VSI hysteresis current control loop is used.

A. *PV MPPT algorithm*

To enhancing the efficiency of the photovoltaic panel MPPT is utilized. According to the maximum power point theorem, the output power of any circuit will be maximum whenever source impedance equivalent to the load impedance, so the MPPT algorithm is utilized to the problem of impedance coordination. In this paper work, the Boost Converter is utilized as impedance coordination between input and output by changing the duty cycle of the converter circuit. Favorable position of the Boost is that low to high voltage is acquired from the accessible voltage. Control algorithm, the PV voltage and current are sensed and then estimate the power, after that find the change in power and voltage by comparing the previous power and voltage; if change in power is zero then duty cycle will be same as previous otherwise duty cycle will change according to the fallowed condition;

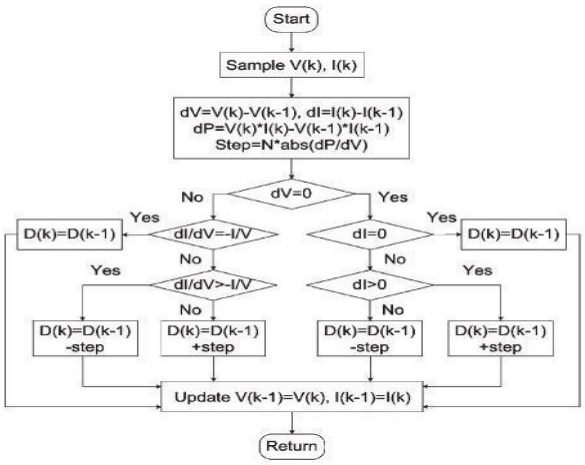

Fig. 3: INC Control algorithm

B. *Inverter Control Scheme*

In Fig. 4 control scheme for three phase voltage source inverter, here hysteresis current loop control is use to generate reference signal and obtained reference signal are passes through relay which generate digital on off signal for switch, these digital signal are responsible for switching of inverter. Propose system is operate in grid connected PV system so to obtaining desired voltage 230 volt line to line and 50Hz frequency reference signal are generate by PI controller and current loop which is shown in Fig. 4. And from these signal theta is obtained using phase locked loop (PLL). Load current are converted from abc frame into dq0 frame using Clark and park transformation so that less PI controller are required, To generate pulses Actual Dc link voltage and reference dc link voltage are comparing using comparator this voltage error signal is passes through PI controller. These PI controller convert voltage signal into current signal and improve the steady state response. This current signal is added with Id component of load current and subtracted from actual PV direct current component this dq0 current component is converted into abc reference frame using inverse Clark and park transformation. These abc signal in compare with source (into the grid from solar surpluses energy) current in abc form and through these reference current signal passes through the relay which is

work as hysteresis loop and generate switching signal. In this way switching signal are generated.

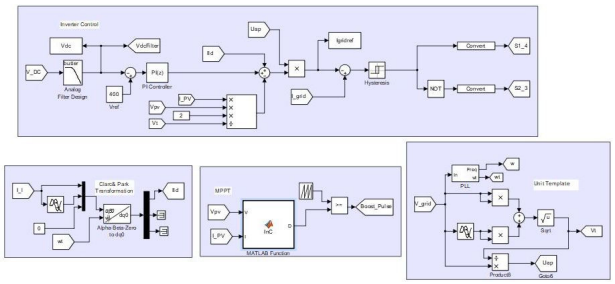

Fig. 4: Control Scheme for single phase voltage source inverter

V. RESULTS AND DISCUSSION

The proposed sustainable energy based grid connected solar power system is modelled in Simulink of MATLAB R2015a with discreet solver at 10µS the developed model is tested under different conditions such as change in change in solar irradiation, and different load condition. Performance is evaluated in terms of solar irradiation G(t) in w/m^2 , PV voltage (V_{PV}) , PV current (I_{PV}), boost converter output current (I_{dc}), power generated by PV module is (Pgpv), DC voltage (V_{dc}), load voltage (V_{Labc}) , load current (I_{Labc}) Load power demand active (P_L) and reactive power (Q_L), grid voltage (V_{gabc}) grid current (I_{gabc}) active power in or from grid (P_g), reactive power in or from grid (Q_g), its voltage THDs, Converter output current (I_{Cabc}) converter output Active power (P_c) and converter reactive power (Q_c)

A. Performance of PV system under varying in solar irradiation

Fig. 5 show the performance of PV system under varying in solar irradiation firstly solar irradiation varies from 800w/m^2 to 1000 w/m^2 till 0.8 to 1.5 second. Because of these solar radiations is varying current of PV panel will be varying so power is increasing from 1.5kW to 2kW. And fig. 6 shows the performance at rated conditions.

B. Performance of PV system under sudden falling in solar irradiation

Fig. 7 shows the performance of PV system under sudden falling in solar irradiation from 1000 w/m^2 to 500 w/m^2.To extract the maximum power, power generation via PV system is from 2kW to 800W.

C. Steady state Performance of system

Fig. Fig. 8 shows the performance of proposed single phase solar rooftop system under steady state conditions. Fig. 4.4 is depicted for time 1.6s-2s whereas solar irradiations is rated that means 1000w/m2 and load demand is zero; hence total PV power is injected to the grid. it is observer that dc link voltage is constant of 400V. The grid injected current is just out of phase and it power factor is unity

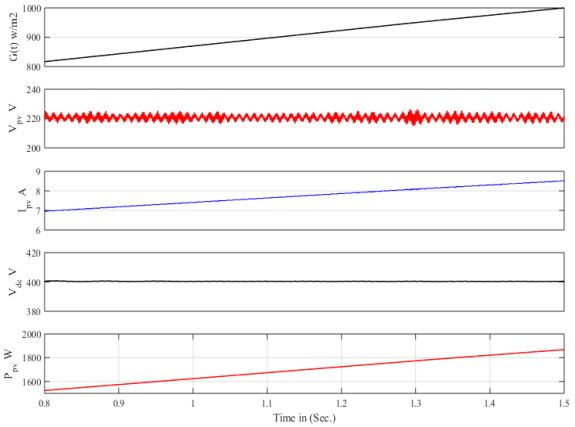

Fig. 5: Performance of PV system under varying solar irradiation.

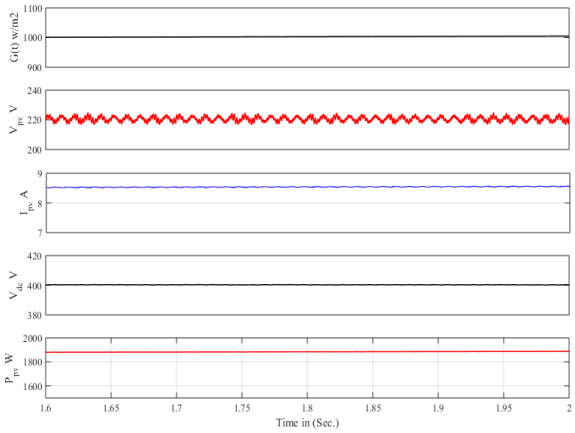

Fig. 6: Performance of PV system under rated in solar irradiation

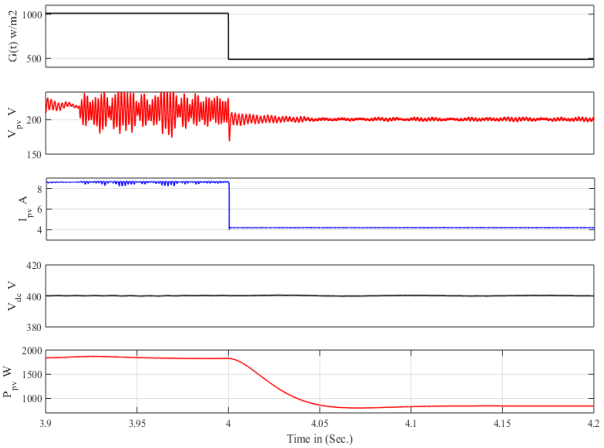

Fig. 7: Performance of PV system under sudden falling in solar irradiation

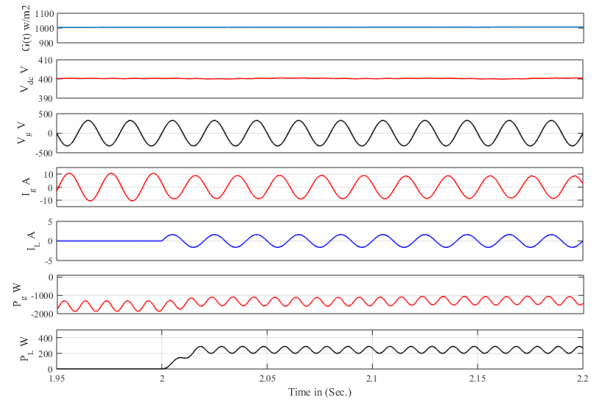

Fig. 8: Steady state performance of single phase solar rooftop system

D. *Power quality analysis grid current*

Fig 9 shows the voltage waves of grid current of and its THDs analysed and observed that THDs was 1.6% with non linearity's nature of load on grid. it is under the IEEE standard. This is possible due to control strategy of inverter.

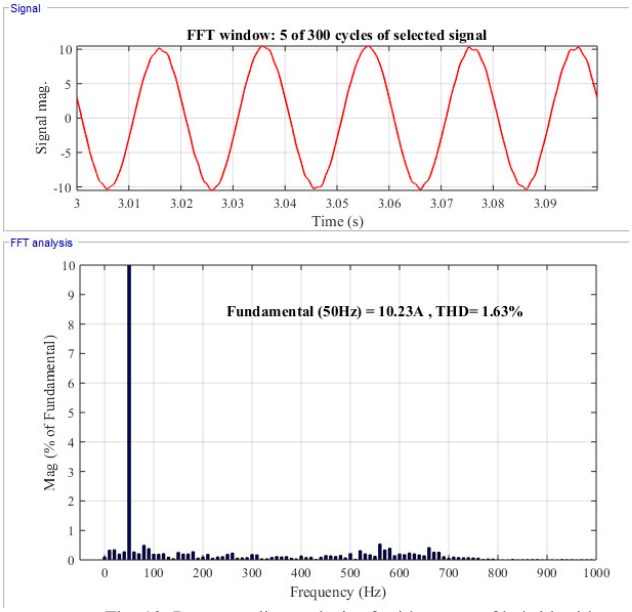

Fig. 10: Power quality analysis of grid current of hybrid grid connected power system

VI. CONCLUSION

A Modelling and Design of Single Phase Solar Photovoltaic Roof-Top System has been proposed. To extract maximum power from natural solar energy INC control method is implementing on boost converter while to synchronies grid inverter hysteresis current loop control scheme is developed on matlab 2015a simpower tool. The proposed sustainable energy based grid connected solar power system performance has verified under various operating conditions and satisfactory performance has been obtained.

Appendix

Dc link voltage V_{dc}= 400V, boost converter inductor = 2mH, dc link capacitor = 2000µF, switching frequency = 10 kHz, series inductor filter L=3mH, shunt voltage ripple filter C=25µF, damping resistance =1Ω, Sampling time T_s=10µs,

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