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Simulation of grid connected photovoltaic power generation

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Abstract- This work deals with the performance and responses of a grid connected photovoltaic (PV) plant in normal and distributed modes. The system is composed of a solar array, a boost converter and a three phase inverter connected to utility grid. An active and reactive power control approach (PQ) has been presented for inverter. This method can provide a current with sinusoidal waveform and ensure a high quality factor. Therefore, the grid interface inverter transfers the energy drawn from the PV into the microscopic energy representation methods. The simulation under MATLAB/SIMULINK result shows the control performance and dynamic behavior of grid-connected PV system in normal and distributed modes.

Keywords*- PV array, MPPT, Boost Converter, P&O Technique.*

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I. INTRODUCTION

The fossil fuel and nuclear fission are the energy sources which are needed to produce electric power. The burning of fossil fuel produces the harmful gases and other toxic metals to the environment. In case of nuclear fission, material will remain deadly for thousands of year and produces radioactive waste. Renewable energies are playing a vital role in supplying the world's required power demands. The photovoltaic power generation system keeps growing in the last few decades to produce promising source of energy. Solar energy is so enormous and free in most parts of the world has become economical source of energy in many applications. On a clear sunny day the sun's radiation reaching on the earth can be 3000 watts per square meter depending on the location. The photovoltaic process is completely solid state and self-contained and there is no moving parts and no materials are consumed. Ancient civilization used solar energy for various purposes.

Because of the above mentioned advantage the photovoltaic system is growing exponentially worldwide. It is recognized as a promising source of renewable energy. Majority of nations have installed the grid connected photovoltaic system to provide alternate source of energy. Of course, the main drawback of the grid connected photovoltaic system is variable irradiance and ambient temperature, so it must be supplemented by the additional technology to supply the demand curve.

1 SOLAR POWER GENERATION IN INDIA

India's produced solar energy was less than 1% of the total energy demand in 2007.The grid-connected generated solar energy as of December 2010 was 10 MW. 25.1 MW and 468.3 MW solar energy productions were added in 2010 and in 2011 respectively. Installed grid connected solar power had increased to 2,766 MW by end September 2014 and expected to install by 2017 an 10,000 MW additional and a total of 20,000 MW by 2022.

2 Photovoltaic array modelling

One of the main ways to use the solar energy is the use of photovoltaic systems or briefly PV. Photo means light and voltaic means electricity. All these cells have one or more electric fields that result in making voltage. The phenomenon that generates electricity because of light without using the driving mechanism is called photovoltaic and any system using this phenomenon is called photovoltaic system. Using photovoltaic systems gives us the ability to keep the environment clean, because the photovoltaic power generation system has very little side effects on nature and unlike fossil fuels that are non-renewable and will be finished one day. Recently, the system of source connection to PV network has become one of the growing sectors in residential applications in Europe, Japan and America. PV system can operate in any weather condition. It is true that in the cloudy or rainy weather, amount of electricity production decreases; however, this amount is never less than 25% of maximum capacity of energy generation system during a day. While in normal conditions, it will generate electricity up to 80% of maximum generation amount.

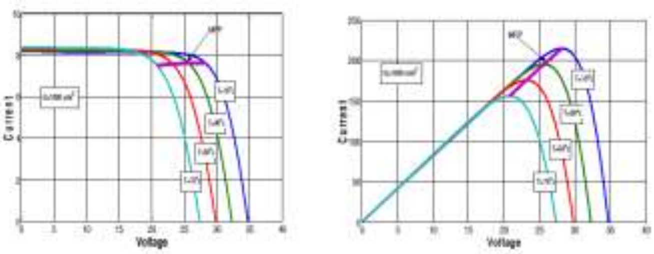


Fig. 1 Current-voltage characteristic and power-voltage solar array during temperature changes

Figure 1 shows the effect of temperature changes on the characteristic curve shows a solar module, as has been noted an increase in temperature leads to a reduction of the open circuit voltage of the module and also reduce the maximum power point voltage, resulting in reduced power output of module.

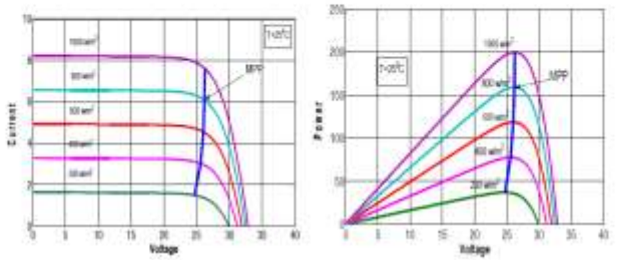


Fig. 2 Current-voltage characteristic and power-voltage solar array during the incident light intensity changes

Figure 2 shows the effect of changes in the intensity of incident light on the characteristic curve of the solar array, as has been observed, decreasing in the light intensity, leading to reduce the photovoltaic flow and thus reducing the output power.

I. PV CELL MODEL

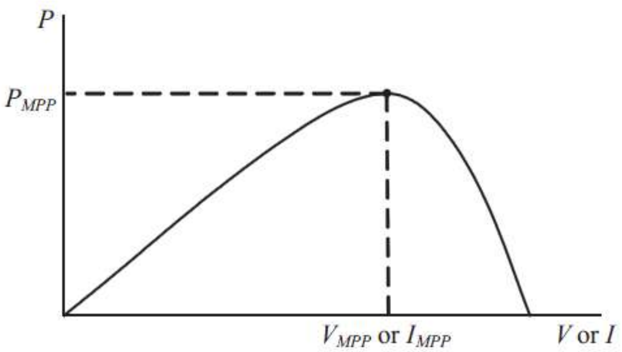


Fig. 3 power curve in terms of voltage or current of the PV array

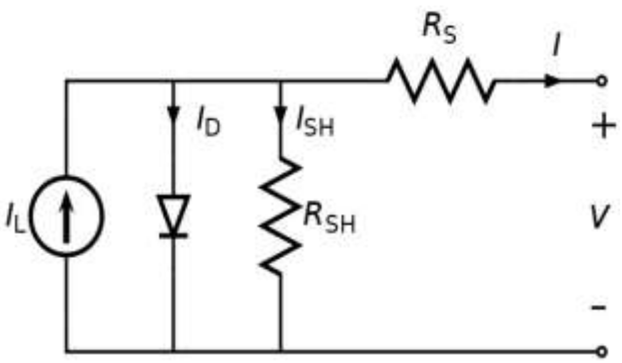


Fig. 4 The equivalent circuit of a solar cell

$$I = I_{ph} - I_{RP} - I_D \qquad (1)$$

$$I_{RP} = \frac{V_m + R_S I_m}{R_P} \qquad (2)$$

$$I_D = I_s \left(\exp\left(\frac{V_m + R_S I_m}{m \eta V_T} \right) - 1 \right) \qquad (3)$$

3 MAXIMUM POWER TRACKING (MPPT)

To implement a system that has the ability to track the maximum power point, it is necessary that the system has components including PV array, DC/DC converter and a programmable controller to apply algorithms of MPPT.

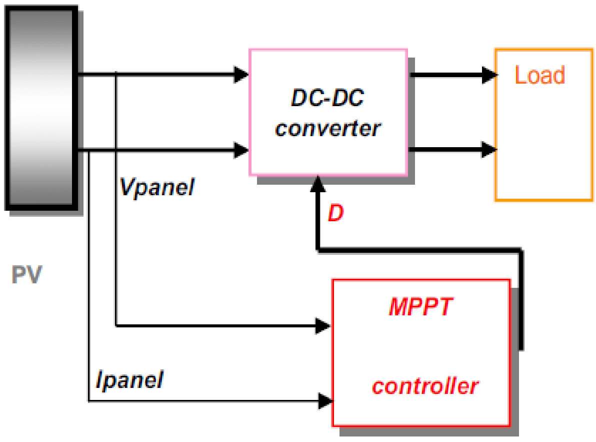


Fig. 5 Block diagram MPPT controller

The performance of solar arrays is defined by two I-V and P-V curves. Those methods are called MPPT (maximum power point tracking). The mentioned problem in MPPT methods is to find voltage of maximum point automatically (VMPP) or current of maximum point (IMPP) of photovoltaic is affected by light and temperature changes in order to achieve maximum output power (PMPP).

4 Control of the boost converter with MPPT controller

From the characteristic I-V and P-V curves of photovoltaic modules, it is shown that there was a unique point for the maximum power (PMPP). This point is defined as the maximum power point (MPP) with the optimal voltage V_{mpp} and the optimal current I_{mpp}. perturb and observe are used: reduced perturbation step size, variable step size, three points weights comparison methods and optimized sampling rate.

Fig.3.22described the flow chart of perturb and observe method. At the input, there are the photovoltaic voltage and photovoltaic current. The power is then calculated from those two parameters. The sign of the power determines the duty cycle output of the MPP controller. In simulation, the duty ratio of the boost converter is the control variable. Perturbing the duty ratio of the converter perturbs the PV array current Ipv and consequently perturbs the PV array voltage. The initial value of the duty cycle and PV power are given. The voltage and current of the PV array are measured first and then the power P is calculated. The power is then compared with the previous value. If the difference is positive, the duty cycle is incremented. The switch used is ideal and the boost output voltage is supposed to be constant. The range of the duty cycles limited between zero and one to ensure that the boost will step up the input voltage within limit.

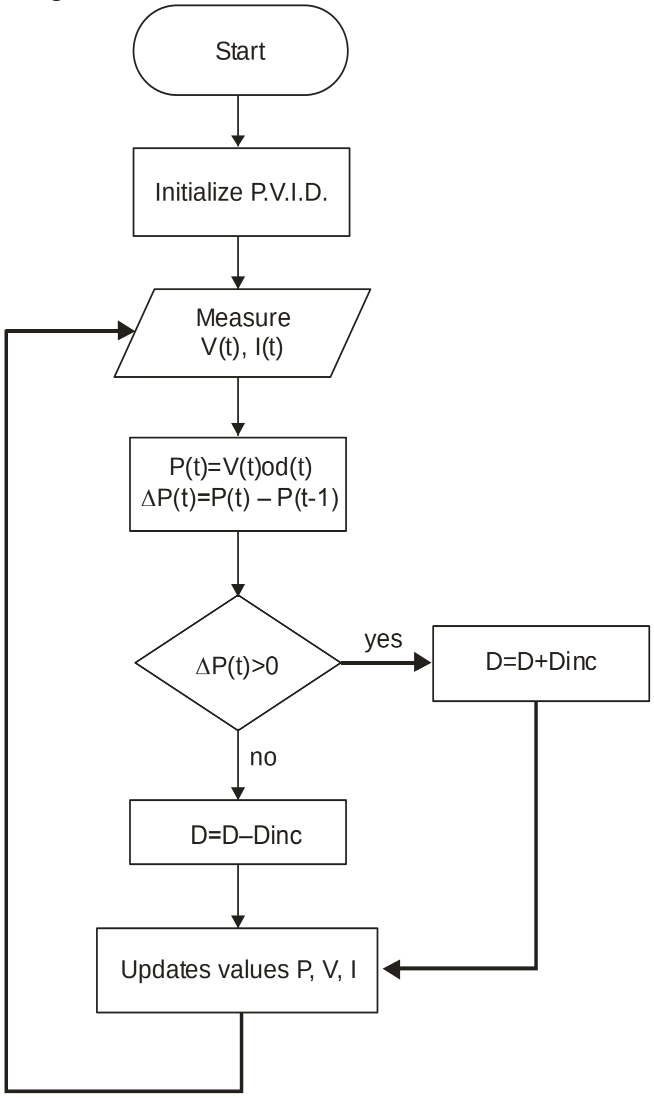


Fig.3.21: Flow chart for P&O

5 SVPWM Modulation Strategy

The three-phase power inverter is the same represented in Fig.3.14.There are six power switchesS1 to S6. Each of them are controlled by individual switching variables which are obtained from the principles of space vector PWM. The three-phase voltage in abc reference frame should be represented in dq reference frame for the Space vector PWM. The output voltages can be represented in the space as set of vectors. These vectors correspond to switching combinations for the inverter switches. There are eight combinations for the voltage output as is made evident in Fig.3.16.

The three phase output voltages in the full bridge inverter at any instant of time can be represented by a set of eight base space vectors as per the eight positions of switching in terms of the inverter. The principle of Space vector PWM is one cycle of the output voltage that can be represented by six sectors (60˚ each). A rotating reference voltage Vref that is calculated through an estimate based on 3 adjacent vectors represent the desired output voltage.

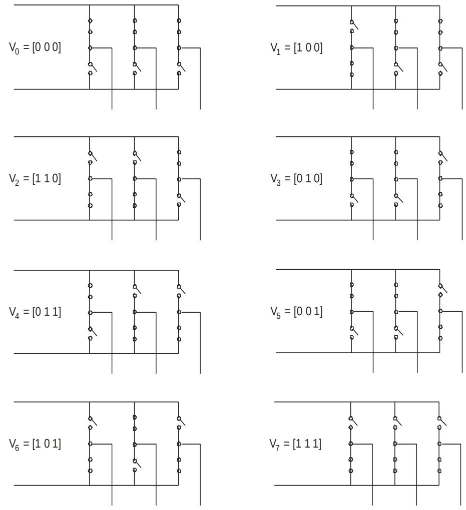
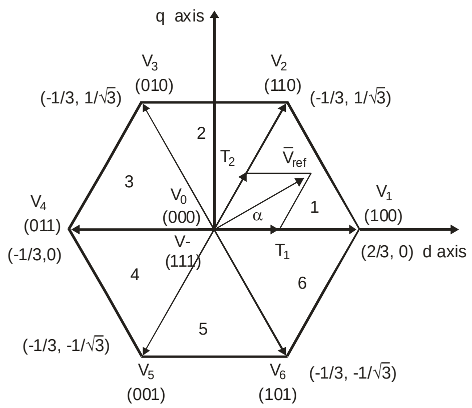


Fig.3.16 Eight switching states



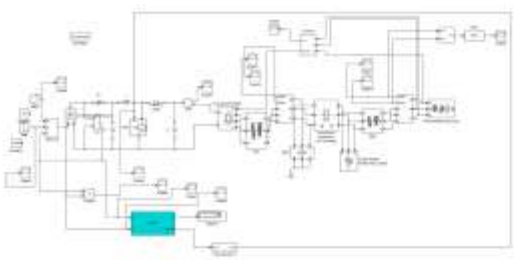


Fig.4.1: Proposed grid connected PV system

II. RESULTS AND DISCUSSION

In this chapter, simulation results of developed grid connected PV system under different conditions i.e. under different temperature, irradiation level are presented to validate the developed controls and MPPT for the proposed model. The boost converter acts as a MPPT tracker is developed. Maximum power tracking for different environmental conditions is confirmed by the optimal power extracted from the PV array and low ripple content in the PV power output around MPP. Fig 1 shows the grid connected PV system model using Matlab/Simulink environment.

6 Steady state operation of grid connected PV system:

In this case the performance of grid connected PV system is investigated under constant solar irradiance G= 1000 W/m2, T=25°C with MPPT algorithm. The PV array is operated at maximum voltage of 25V, maximum current of 8 A, thus, has a maximum output power of 2,00W. When the system is in steady state, the solar insolation is 1000 W/m2, and the environmental temperature is 25^0**C**. From figure it is clear that in case of steady state operation, the operation point of PV panel is just its maximum power point. The efficiency of the proposed system depends on the intensity level. When the irradiance level is high, the proposed system can deliver more power to the electric grid.

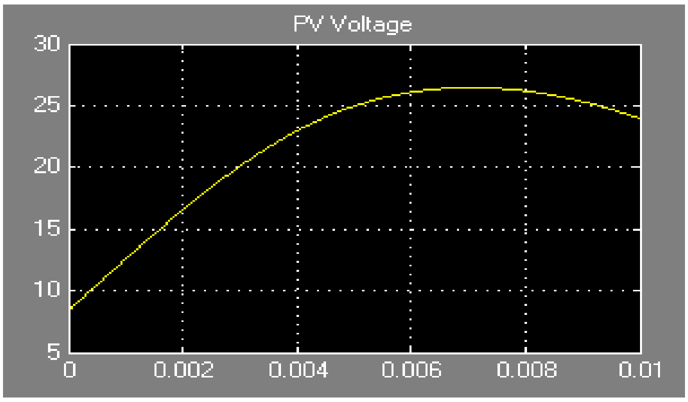


Fig.4.4:PV voltage at steady state

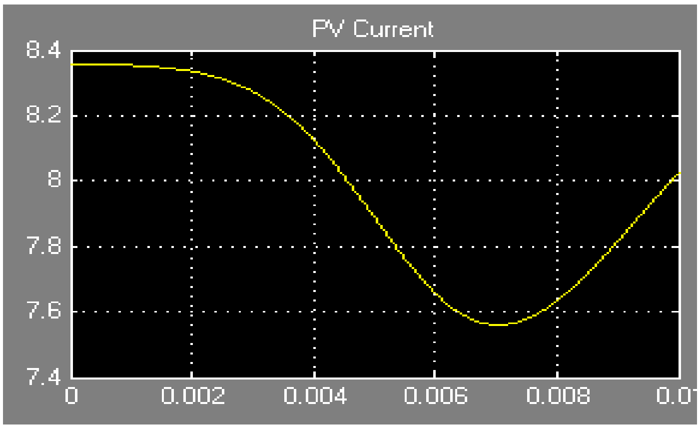


Fig.4.5:PV current at steady state

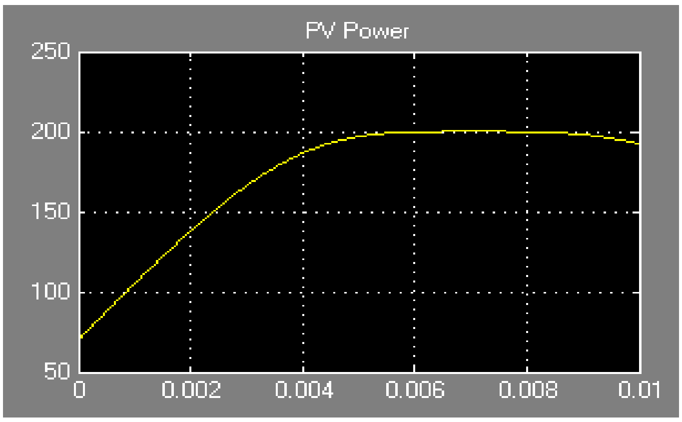


Fig.4.6:PV power at steady state

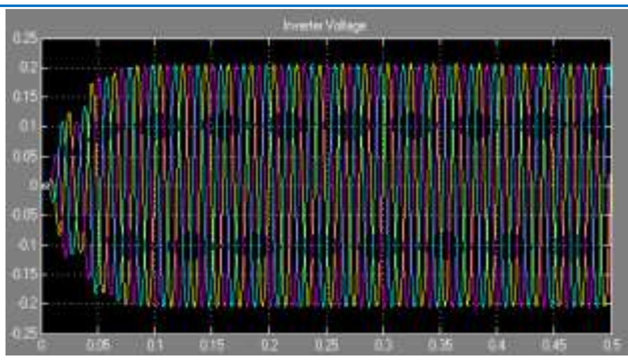


Fig.4.8:Inverter voltage at steady state

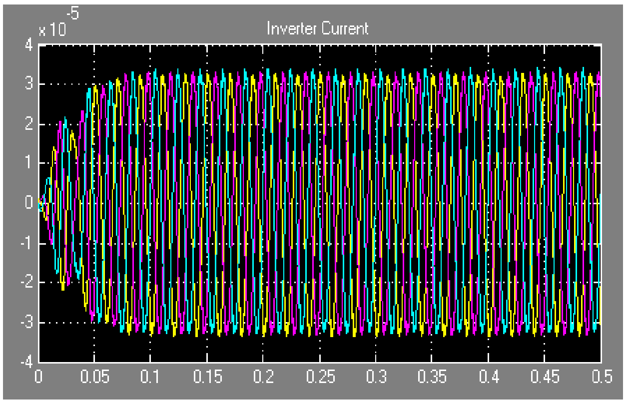


Fig.4.9:Inverter current at steady state

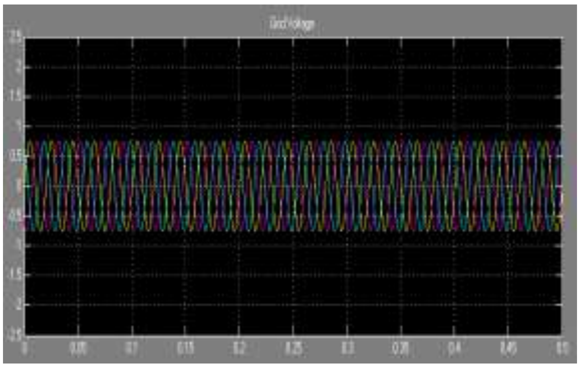


Fig.4.10:Grid voltage at steady state

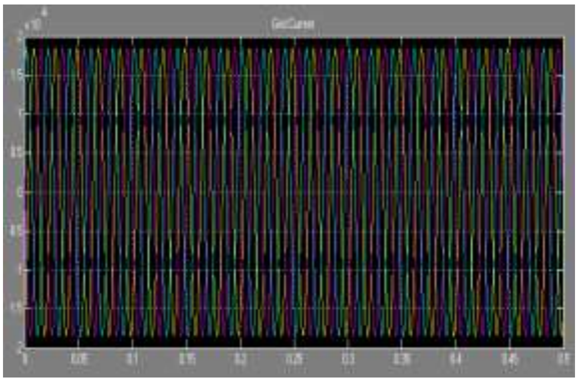


Fig.4.11:Grid current at steady state

7 Dynamic operation of grid connected PV system

In this case the performance of the grid connected PV system is investigated under variable solar irradiance and ambient temperature. The PV array is operated at maximum voltage of 25 V ,maximum current of 8 A and maximum power of 200 W. The main objective of the implementation of simulation was to investigate the dynamic response of the proposed system at variable irradiance and environmental temperature. When cloud passes by and blocks direct sunlight from hitting the PV panel this type of situation arises. The solar panel was subjected to sudden change in insolation level from 1000 to 200 W/m^2. An immediate effect on solar current and solar voltage due to the sudden change in insolation level at 0.005 sec has shown in Fig .

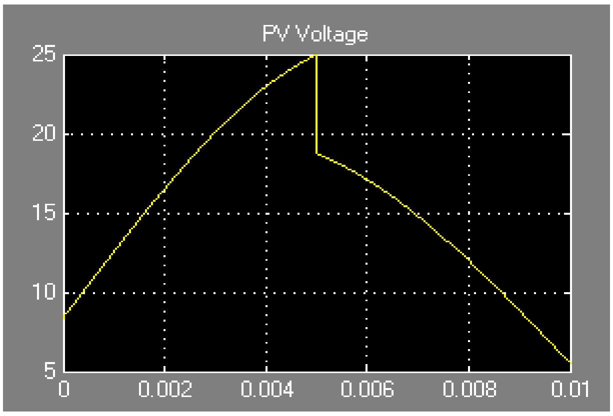


Fig.4.15:PV voltage at dynamic state operation

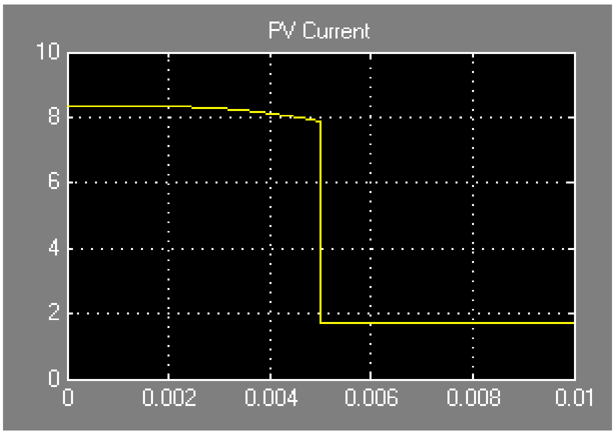


Fig.4.16:PV current at dynamic state operation

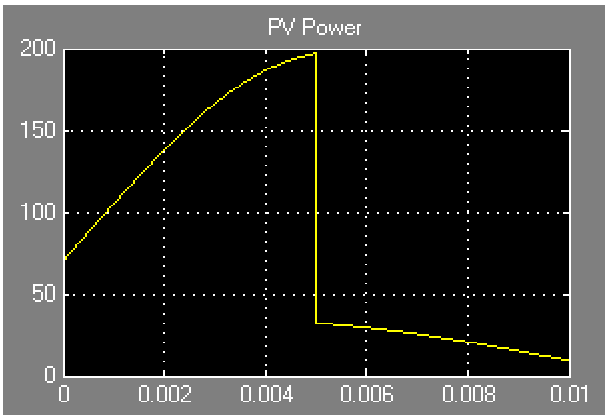


Fig.4.17:PV power at dynamic state operation

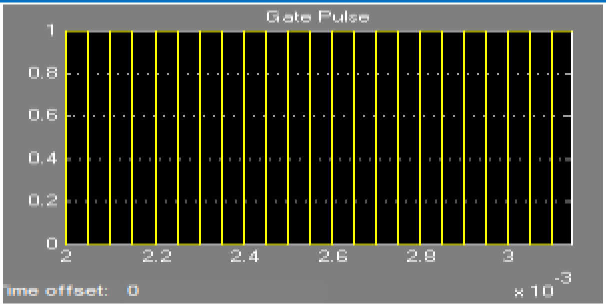


Fig.4.18: Gate pulse for IGBT of boost converter at dynamic state operation

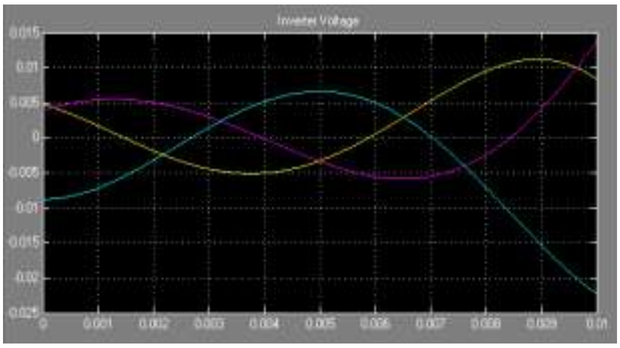


Fig.4.19:Inverter voltage at dynamic state

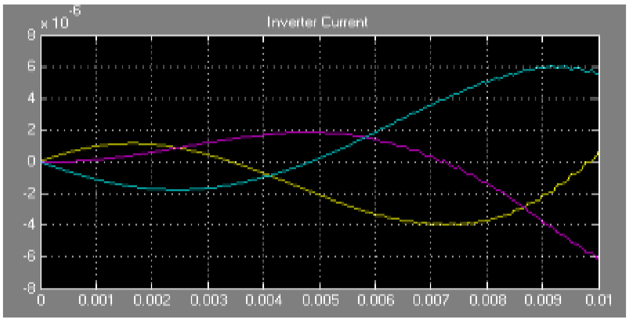


Fig.4.20:Inverter current at dynamic state

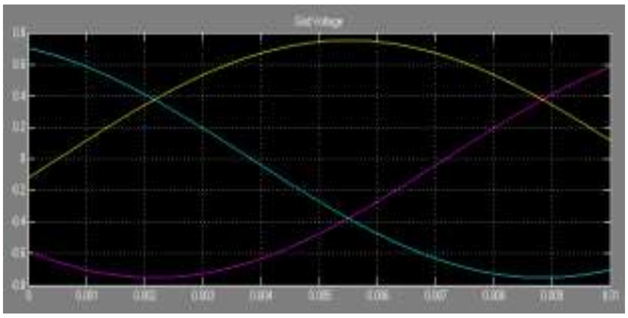


Fig.4.21:Grid voltage at dynamic state

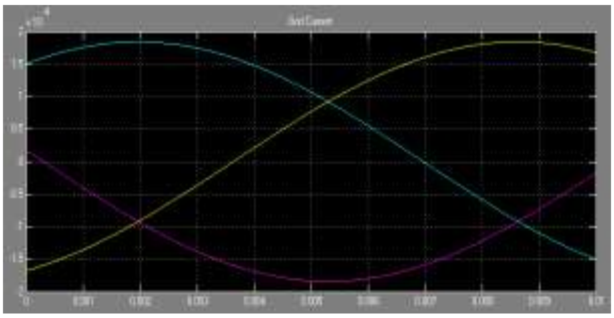


Fig.4.22:Grid current at dynamic state

III. CONCLUSION

From Available power distribution standalone and grid many MPPT techniques are used, to select a particular MPPT for a system deals with cost, reliability, speed and safety of the system. Paper gives us a brief description PV panel working with Grid along with MPPT The whole panel MPPT-Grid tied system is created in MATLAB/Simulink. PV panel Simulink block under gone I_V, P-V characteristic check and results similar to real time conditions is obtained.

IV. REFERNCES

[1] Martina, C. and Hartmut 1998. "A Ripple Based Maximum Power Point Tracking Algorithm for A Single-Phase, Grid Connected Photovoltaic System". Solar Energy, 63(5):277-282.

[2] Eftichios, K., Kostas,K.,Nicholas,C. and Voulgris 2001."Development of a Microcontroller-Based, Photovoltaic Maximum Power Point Tracking Control System", **IEEE Transactions on Power Electronics, 16(1)**:46-54.

[3] Eduardo, R., Ricardo, A., Pedro, I., Sabino, E. and Damian 2006. "Intelligent PV Module for Grid-Connected PV System", IEEE Transactions on Industrial Electronics, 53(4):1066-1073.

[4] Harouni, N., Jraidi, M. and Cherif 2008. "New control strategy for 2-stage grid-connected photovoltaic power system", Science Direct [Online]. Available: http://www.elsevier.com/locate/renene.

[5] Molina, M, G. and Mercado 2008. "Modeling and Control of Grid-connected photovoltaic energy conversion system used as dispersed generator" , IEEE transaction 2008.

[6] Mastromauro, A, R. and Kerekes 2009. "A single phase voltage-controlled grid connected photovoltaic system with power quality conditioner functionality", IEEE Transaction on Industrial Electronics 56(11):4436-4444.

[7] Ding, F., Li, P., Huang, B., Gao, F., Ding, C. and Wang 2010. "Modeling and Simulation of Grid-Connected Hybrid photovoltaic/Battery Distributed Generation System" , China International Conference on Electricity Distribution.

[8] Wang, Z., Li, G. and Yue 2011. "Studies of Multi-Type Composite Energy Storage for the Photovoltaic Generation System in Micro-grid", IEEE Transaction 2011.

[9] Abdelsalam, K. A. and Ahmed 2011. "High-Performance Adaptive Perturb and observe MPPT Technique for Photovoltaic-Based Micro-grids", IEEE Transactions on Power Electronics 26(4):1010-1020.

[10] Chitra, A., Giridharam, K. and Chellamuthu 2011. "Grid connected inverter with SVPWM technique for photovoltaic application". Available online at www.elixirpublishers.com :4438-4442.

[11] Mossoba, J., Kromer, M., Faill, P., Katz, S., Borowy, B., Nichols, S and Casey 2012. "Analysis of Solar Irradiance Intermittency Mitigation Using Constant DC Voltage PV and EV Battery Storage", IEEE Transactions.

[12] Yang C., Yu, Hsieh C., Yu, Feng F., Kuei and Chen 2012. "Highly Efficeint Analog Maximum Power Point Tracking (AMPPT) in a Photovoltaic System", IEEE Transactions on Circuit and Systems 59(7):1546-1556.

[13] Bidram, A., Davoudi, A. and Balog 2012. "Control and Circuit Techniques to Mitigate Partial Shading Effects in Photovoltaic Array", IEEE Transactions of Photovoltaic 2(4):532-546.

[14] Tan, K., T., So, P., L., Chu, Y., C. and Chen 2013. "Coordinated Control and Energy Management of Distributed Generation Inverters in Microgrid", IEEE Transaction on Power Delivery 28(2):704-712.

[15] Chen, S., M., Liang, T., J. and Hu 2013. "Design, Analysis, and Implementation of Solar Power Optimizer for DC Distribution System", IEEE Transaction on Power Electronics 28(4):1764-1772.

[16] Chang, Y., C., Kuo, C., L., Sun, K., H. and Li 2013. "Development and Operational Control of Two String Maximum Power Point Trackers in DC Distribution System", IEEE Transaction on Power Electronics 28(4):1852-1861.

[17] Xiao, W., Zeineldin, H., H. and Zhang 2013. "Statistic and Parallel Testing Procedure for Evaluating Maximum Power Point Tracking Algorithms of Photovoltaic Power Systems", IEEE Journal of Photovoltaic 3(3):1062-1069.

[18] Lazarov, V., Zarkov, Z., Stoyanov, L., Kanchev, H. and Francois 2013. "Grid-connected PV System with MPPT Control", available at Research Gate articles http://www.researchgate.net/publication/247777365.

[19] Kontogiannis, K., P., Vokas, G., A., Nanou, S. and Papathanassiou 2013. "Power Quality Field Measurments on PV Inverter". International Journal of Advanced research in Electrical, Electronics and Instrumentation Engineering.

[20] Trivedi, A., Bhavsar, F. and Balar 2014. Novel Control Strategy for Grid-Connected PV System With Reactive Power Compensation and MPPT Control. International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering (IJIREEICE) 2(5):1472-1476.

[21] Phalke, J., D. and Kulkarni 2014. "Grid Tied Solar Inverter at Distribution level with Power Quality Improvement". International Journal of Engineering Science and Computing (IJESC):765-769.

[22] Mathew, S., G. and Chacko 2014. "Power Quality Improvement in Grid Connected Renewable Energy system". Second International Conference on 10th August 2014, Cichin, India, ISBN: 978-93-84209-8.

[23] Ramya, G. and Ramaprabha 2014. "Performance Enhancement of Photovoltaic System Using Soft Switched Multi-phase Boost Converter", Journal of Electrical System (JES):381-391.

[24] Ganesh, R., and Dr. Kumar 2014. "Evaluation of STATCOM for Grid Connected PV System", Journal of Theoretical and applied information technology: 683-689.

[25] Francis, W., K., Beevi, S. and Mathew 2014. "MATLAB/Simulink PV Modulr Model of P&O and DC link CDC MPPT Algorithms with Lab view Real Time Monitoring and Control Over P&O Technique", International Journal of advanced research in Electrical, Electronics and Instrumentation Engineering: 92-100.