IJCTA, 9(41), 2016, pp. 279-288 ISSN: 0974-5572

Power Quality Comparison of Standalone PV Plant Under Different Conditions by Using ANN

Vaibhav Shukla* and Abhishek Kumar Sinha**

ABSTRACT

In this paper the Simulink model is made with a battery as an energy storing element and provides energy at time of unavailability of solar irradiation. MATLAB /Simulink has been used to develop the model. The proposed system consists of PV-array of 100KW, a DC-DC boost Converter with MPPT control by using Artificial Neural Network, a bi-directional dc-dc converter to charge and discharge the battery, a battery, a three phase PWM inverter to supply the ac power to load with Voltage and frequency control and a variable load. The battery used has characteristic of fast charging and slow discharging to provide reliable power supply for a standalone system. Three types of control are proposed in this paper namely the MPPT control for getting maximum and constant power outputfrom PV array and the second control is proposed in bi-directional dc- dc converter to ensure the charging and discharging of the battery and last but not least is control of inverter to get constant voltage and constant frequency output with variable load.

Keywords: MPPT; Bi-directional dc-dc converter; P&O method; IC method; ANN; PWM inverter.

1. INTRODUCTION

Because of the exhaustion of fossil fuel and ecological security causes, renewable energy (for example, wind energy, solar energy, tidal energy, geo-thermal energy etc.) has been broadly utilized from last twenty years [1]. Extraordinarily, the Solar power has the totally free, no contamination, low support cost, appropriated through the earth, and no commotion because of not having any mechanical part. In general, two types of solar farm exist, which are characterized by their capacities and setup, in particular namely standalone power system and the power system associated with grid [2] to [5].The stand-alone solar farm is feasible for small power system while the grid associated solar farm is feasible for high power application.

The power outcome from the PV system depends on the Solar Irradiation and ambient temperature and varies accordingly with the variation of Solar Irradiation and ambient temperature. MPPT is required to coordinate the PV outputwith the changing atmospheric conditionsbecause the V-I curve of solar system is nonlinear in nature. Numerous methods of control for MPPT have been developed [6].

This paper describes about the standalone PV system used in standalone applications. Thethree main converters namely step-up dc-dc boost converter, bi-directional dc-dc converter for charging/discharging of battery and dc-ac inverter must work together in a co-ordinate manner to fulfill the local load, with high efficiency output of the system. Capacities for the three converters are MPPT control, control of the dc link voltage and ac voltage and its frequency control individually. Hypothetical examination and simulation outcomes delineate the great performance of the proposed control plans[12].

* Assistant Professor, Department of Electrical Engineering, Seth Vishambhar Nath Institute of Engineering and Technology, Lucknow, India, *Email: shukla.vaibhav@ymail.com*

** Assistant Professor, Department of Electrical Engineering, Lovely Professional University, Punjab, India, *Email: erabhi.sinha2008@gmail.com*

2. PRAPOSED SOLAR SYSTEM

The proposed PV based solar farm is shown in figure-1. All components of this model and their simulation modeling are discussed one by one in this paper.

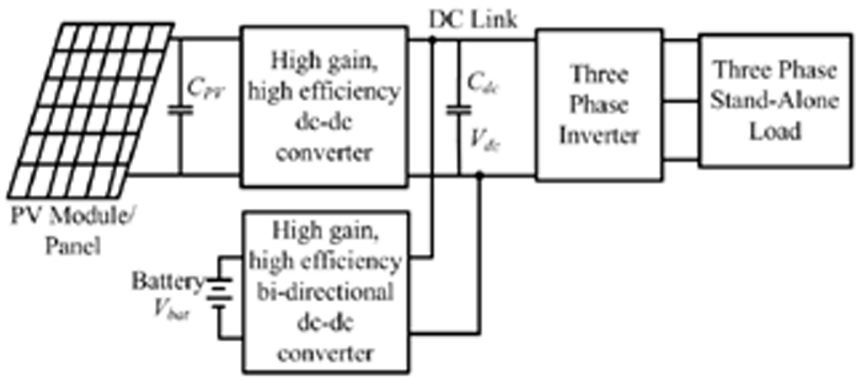


Figure 1: Model of the standalone PV plant

2.1. PV-MODULE

The PV model with single diode is considered for designing of the solar cell [9]. The proposed model characteristic equations are

$$I = I_{\lg} - I_{os} * \left[\exp\left\{ q * \frac{V + I * R_s}{A * k * T} \right\} - 1 \right] - \frac{V + I * R_s}{R_{sh}} \tag{1}$$

$$I_{os} = I_{or} * \left(\frac{T}{T_r} \right)^3 * \left[\exp\left\{ q * E_g * \frac{\frac{1}{T_r} - \frac{1}{T}}{A * k} \right\} \right] \tag{2}$$

$$I_{lg} = \{I_{scr} + Ki\,(T - 25)\}* \tag{3}$$

The number of cells connected in series is called the string and the number of strings connected in parallel is called module, and these number of series and parallel cell decides the characteristic equation of the PV array.

$$I = Np * Ilg - Nplos \left[\exp\left\{ q \frac{\frac{V}{Ns} + I \frac{Rs}{Np}}{AkT} \right\} - 1 \right] - \frac{V\left(\frac{Np}{Ns} \right) + IRs}{Rsh}$$

Where

I_{lg} Light – Generated Current

A Ideality Factor

R_s Series Resistance

R_{sh} Shunt Resistance

Solar Irradiation In W/M^2

K_i	S/C Current Temp Coefficient At I_{scr}
Q	Electron Charge .1.6*10^{-23} C
I_{scr}	Short Circuit Current At 25^0 Celsius
I	Cell Output Current
T	Cell Temperature In Celsius
E_g	Band Gap For Silicon
K	Botlzmann'sConstatnt, 1.38*10^{-19} J/K
T_r	Reference Temperature
I_{or}	Cell Saturation Current At Tr
I_{os}	Cell Reverse Saturation Current
V	Cell Output Voltage

2.2. Boost Converter

The PV array produces dc voltage under all state of irradiation. The produced voltage is low in addition;it must be consistent at the primary level of inverter [7]. So we require a support converter which helps to keep up consistent dc output voltage with maximum power output. BJT, MOSFET or IGBT are used as a switching device in these converters.The base oscillator frequency ought to be around 100 times more than the transistor switching period to augment proficiency [10].

2.3. Bi-Directional DC-DC Converter

The energy storing facility is much important in the case of the standalone PV system, because during the unavailability or presence of insufficient solar irradiant that energy store is used to continue the supply the load. A bi-directional dc-dc converter is used to charge and discharge battery and battery is used as an energy storing element. The use of this type of converter is very essential to keep flow of power in bi-directional from dc link to battery during the sufficient solar irradiant (charging the battery) and battery to dc link during non-availability of sufficient solar irradiant (discharging of battery). The bidirectional dc-dc converter alongside energy storing facility has turned into a promising choice for some power related system, renewable power system. It decreases the expense and enhances efficiency, as well as enhances the execution of the system. In PV generating applications, the various info bidirectional dc-dc converter can be utilized to consolidate diverse sorts of energy sources. This bidirectional dc-dc converter highlights galvanic detachment between the variable load and the energy component, bi-directional flow of power, capacity to coordinate distinctive voltage levels, quick reaction to the transient load variation, and so on. The bi-directional dc-dc converter is regularly used to exchange the solar power to the capacitive energy source during the sufficient solar irradiant, while to convey power to the variable load when the dc link voltage is low. Basically the power electronics switches are used in bi-directional converter. The MOSFET (Metal oxide semiconductor field effect transistor), IGBT (Insulated gate bipolar transistor) or other switches, along with a parallel diode are used in these types of converter. These switches help to keep power flow in only in one direction in one time and reverse in another time. [6]

2.4. PWM Inverter

The PV panel produces DC power while the stand-alone PV system contains AC load. So to overcome this situation, a DC/AC transformation is required. Basically the inverter is a device which converts dc power to ac power and the flow of the power is from dc to ac system. A constant dc voltage is required in the input of the inverter, and the inverter converts this constant dc voltage in to ac voltage of constant frequency of 50 Hz in our system. The pulse width modulation (PWM) type inverter is used in the proposed system. This is, truth be told, the part of the proposed voltage and frequency controller. Really, the converter will change over the data DC power into a AC power with the most ideal productivity.

2.5. Control of Inverter

In standalone solar farm the inverter works as a voltage source and serves the requirementto give a steadyac output. At the point when the load is variable, the active and reactive power requirement at load end varies and contains a lot of low frequency harmonics signal due to sudden variations in voltage and current occur to fulfill the change in the requirement of reactive power. So there is requirement of suitable inverter controller to control the switching of the inverter in such a way that the output of the inverter becomes pure sinusoidal with constant 50 Hz frequency[8].

2.6. Variable Load

In case of standalone power system, the frequently load change occurs with respect to time and affect output voltage level and frequency. Basically variation in load produces the variation in flow of active and reactive power from source to load and these variations creates the variation in voltage level and the frequency.

3. NEURAL NETWORK

A neural network (NN), is a scientific model or computational model that is enlivened by the structure and practical parts of organic neural networks. A neural network comprises of an interconnected gathering of artificial neurons. Normally ANN is a versatile system that changes its structure taking into accounts outside or inside data those passes through the system during the learning stage. Neural networks are typically used to model complex relationship in the middle of inputs and output or to find the patterns of the information [11].

Commonly, neural networks are balanced, or prepared, so that specific information prompts a particular desired output. There, the system is balanced bydoing comparison ofactual output and desired output, until the system outputequals to desired output. Regularly, numerous such data/target sets are expected to prepare a neural network.

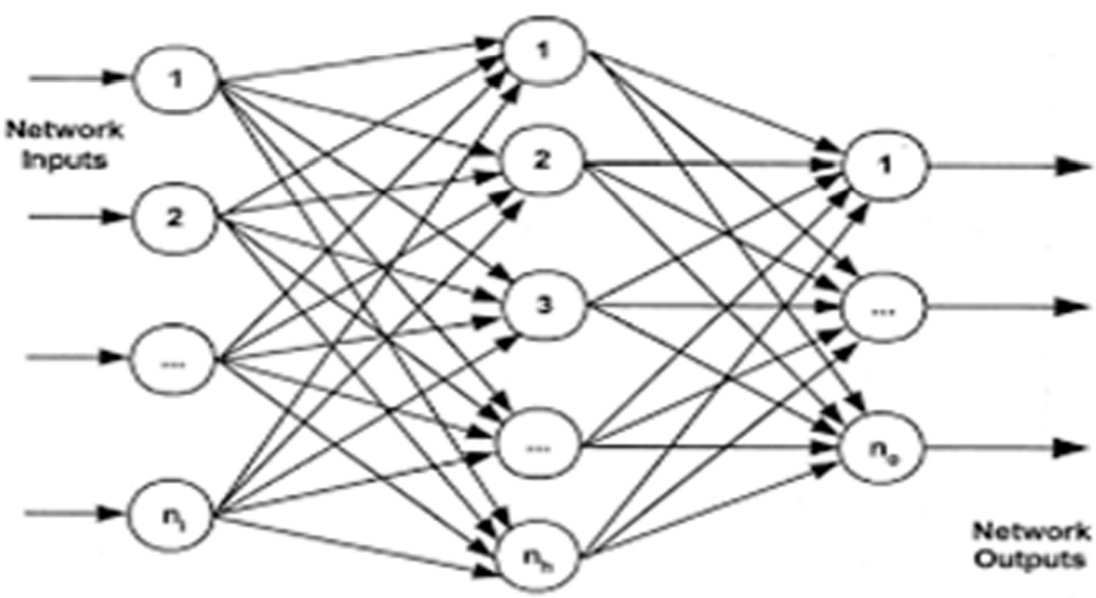


Figure 2: Basic structure of ANN

4. SIMULATION RESULT AND DISCUSSION

The overall model of proposed system is shown in figure-3. The specified parameter of the Solar system and Battery is mentioned in the appendix. For testing the performance of the MPPT and the voltage regulator used in the system, the simulation is carried out under the variable load condition as well as changing climate conditions. There are three case studies are proposed

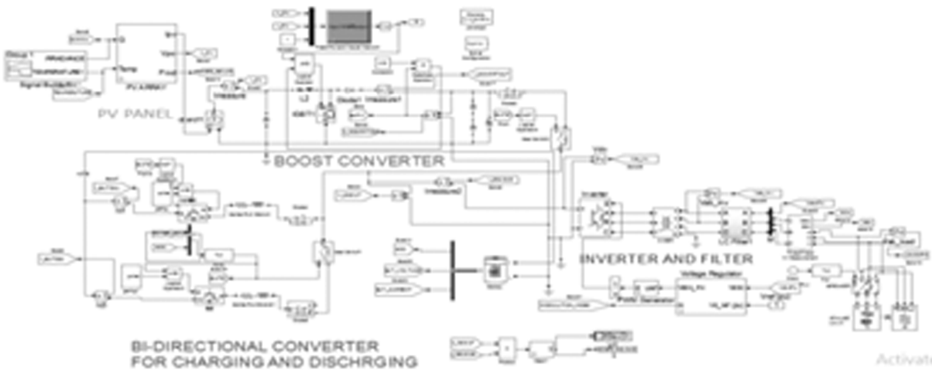
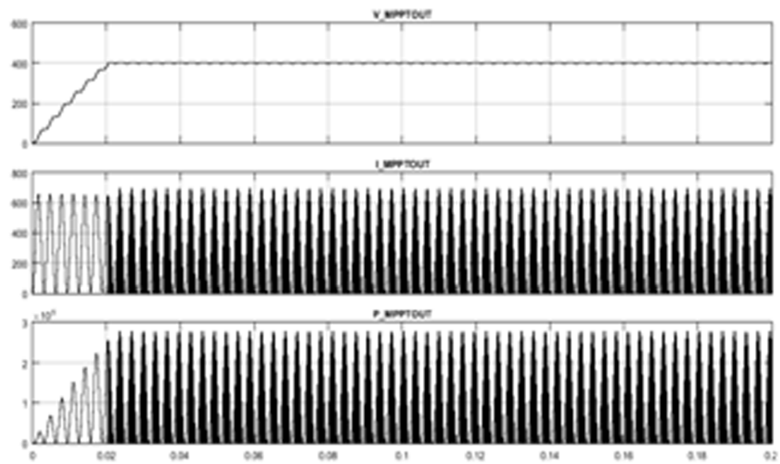


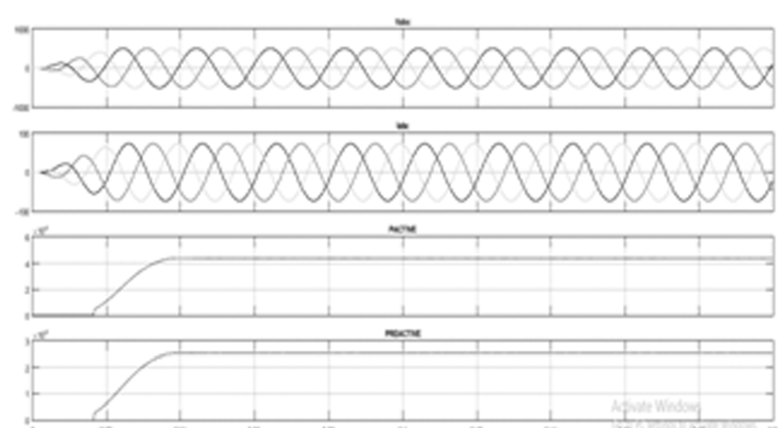
Figure 3: Simulink Model of the proposed system

4.1. Case1- Constant Solar Irradiation with Constant Load

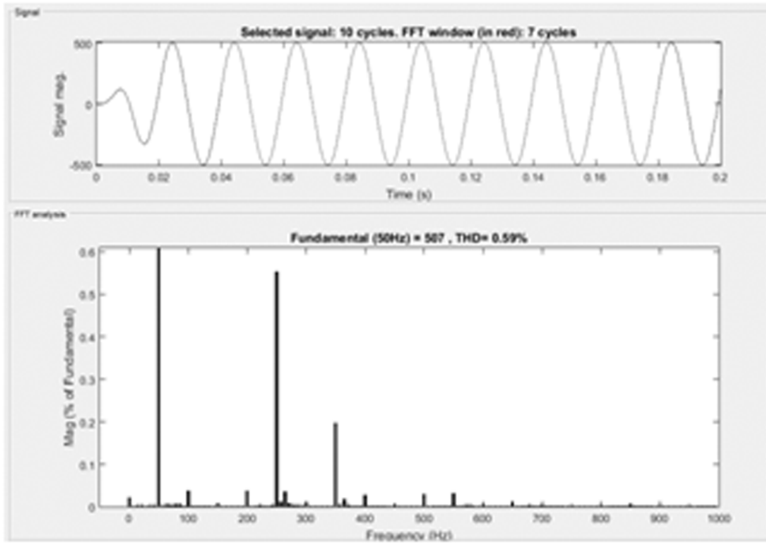
In this case the irradiation is constant 1000W/m^2 and load is constant of 40W for the whole period (0-0.2 s). The solar output waveform, voltage, current and power waveform at load side and THD graph is shown in figure-4.



(a)



(b)

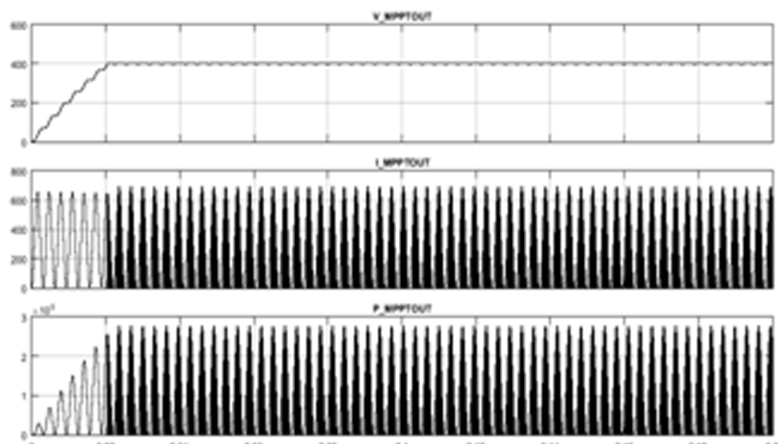


(c)

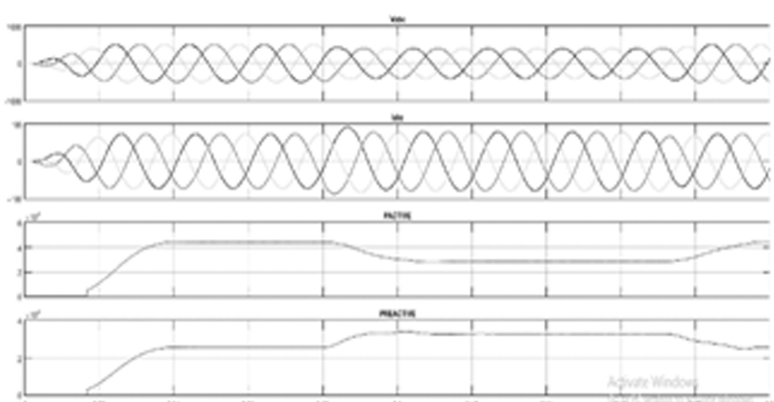
Figure 4: At constant Solar Irradiation and load condition
(a) MPPT output, (b) load voltage, current and power, (c) THD

4.2. Case2- Constant Solar Irradiation with Variable Load

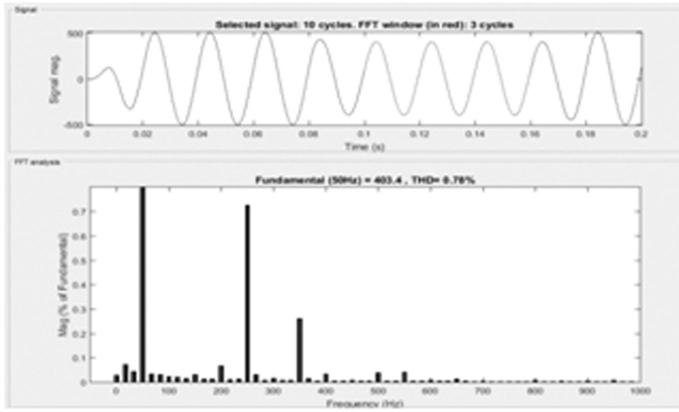
In this case the Solar Irradiation is constant in whole period and the load varies (additional reactive load added with previous load for 90ms (from 0.08s to .17s)). Due to change of load more reactive power



(a)



(b)



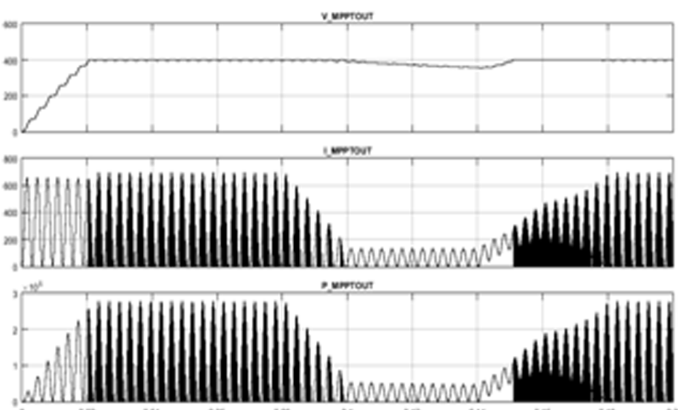
(c)

Figure 5: At constant Solar Irradiation and variable load condition (a)MPPT output(b) output voltage, current and power, (c) THD

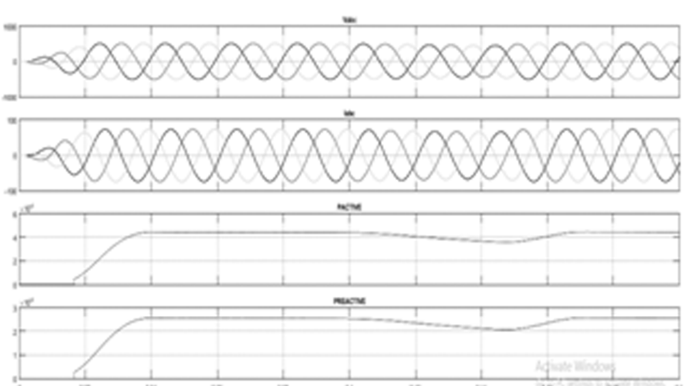
needed, due to this the variation should be shown in the output voltage magnitude as well as frequency. But by choosing the appropriate modulation index of frequency modulator the output frequency remains constant but a small voltage magnitude occurs. The solar output waveform, voltage, current and power waveform at load side and THD graph is shown in figure-5.

4.3. Case3- Constant load with variable Solar Irradiation

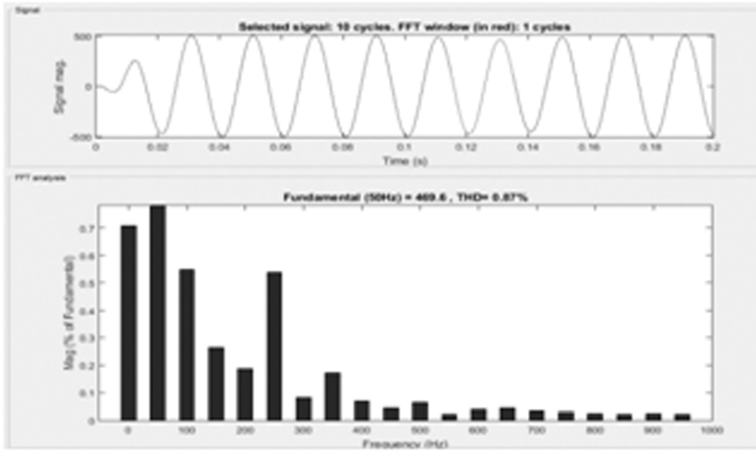
In this case the load is constant for whole period but the Solar Irradiation changes from 1000 W/m^2 to 200 W/m^2 from 0.08s to 0.16 sec. Due to insufficient solar Irradiation the battery stop charging and start



(a)



(b)



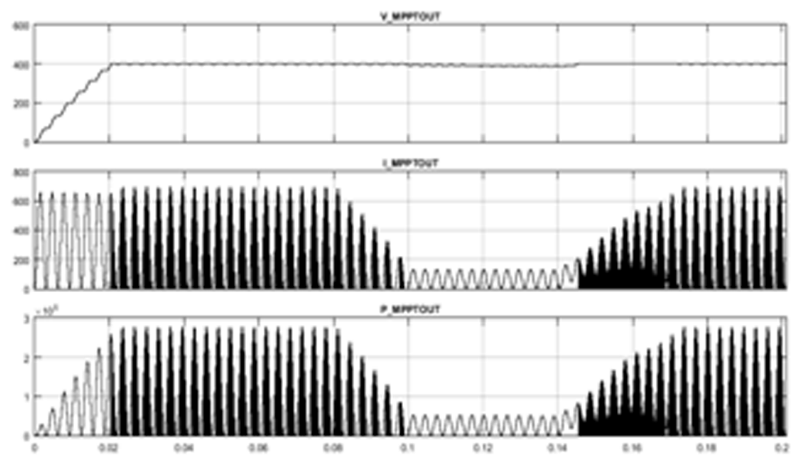
(c)

Figure 6: At variable Solar Irradiation and constant load condition (a) MPPT output, (b) output voltage, current and power, (c) THD

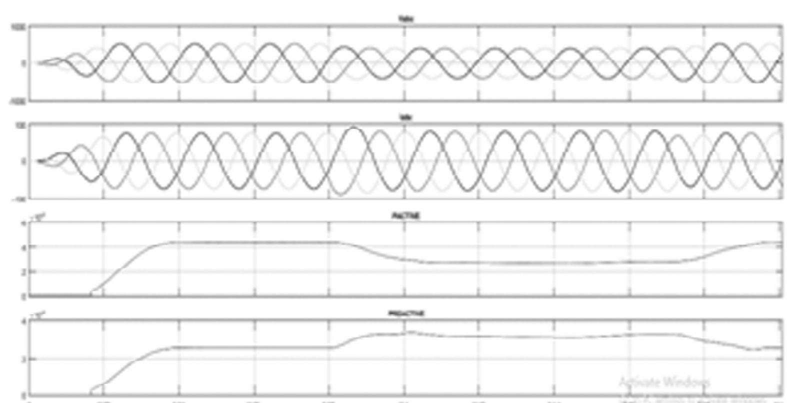
discharging simultaneously and redistribution of power occurs. The solar output waveform, voltage, current and power waveform at load side and THD graph is shown in figure-6.

4.4. Case4- Both Solar Irradiation and Load Varies

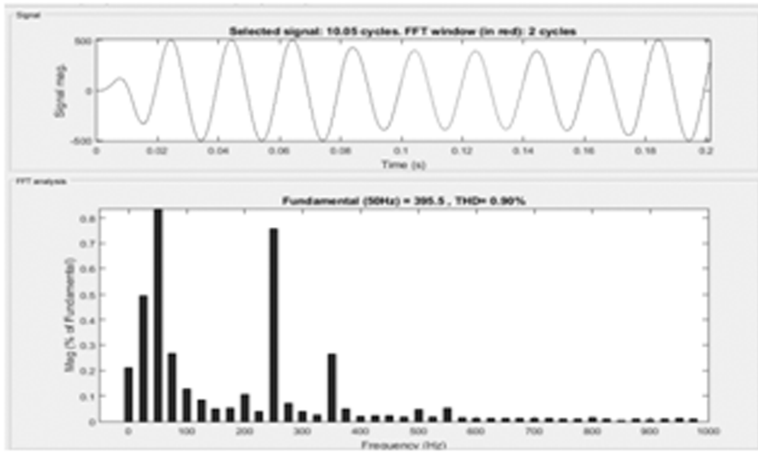
In this case the both load and the Solar Irradiation variation occurs simultaneously from 0.08s to 0.16s. The solar output waveform, voltage, current and power waveform at load side and THD graph is shown in figure-7



(a)



(b)



(c)

Figure 7: At both variable Solar Irradiation and variable load condition (a) MPPToutput, (b) output voltage, current and power, (c) THD

5. CONCLUSION

Due to be harmful for environment and its limited stock, the fusil fuel based electricity generation has to be limited and an alternative non-conventional power resource is needed. Solar power is a versatile power and available everywhere, but to extract the maximum power from solar energy and convert in to electrical power with maximum efficiency is still a challenge. In this paper, it is shown that a standalone power system is continuously powered with PV generation system by using a battery of sufficient capacity. Artificial neural network keeps the dc bus voltage constant and make it more efficient system during the sufficient availability of solar irradiant. The result shows that the output of the system is remain almost constant and the THD is under considerable value in all conditions.

6. FUTURE SCOPE

The voltage unbalance occurs on the load variation as well as variation in solar irradiation due to redistribution of reactive power. This problem can be solved by using an appropriate SVC (static VAr Compensator) and required reactive power is provided by the compensator so as to avoid the redistribution of reactive power in the circuit and hence voltage unbalance can be avoided.

REFERENCES

[1] Felix A. Farret and M. Godoy Simoes, Integration of Alternative Source of Energy. John Wiley & Sons, Inc., 2006.

[2] J F. Fuller, E. F. Fuchs, and K. J Roesler, “Influence of harmonics on power distribution system protection,” IEEE Trans. Power Delivery, voL 3, pp. 549-557, Apr. 1988.

[3] S. Yuvarajan, Dachuan Yu, and ShanguangXu, “A novel power converter for photopvoltaic applications,” Journal of power source, 135, pp. 327-331,2004.

[4] T. L Maris, Sf. Kourtesi, L. Ekonomou, and G. P. Fotis, “Modeling of a single-phase photovoltaic inverter,” Solar Energy Materials and SolarCells, 91, pp. 1713-1725,2007.

[5] Rong-Jong Wai and Wen-Hung Wang, “High-performance stand-alone photovoltaic generation system,” IEEE Trans. Industrial Electronics, VoL 55, No. I, pp. 240-250, Feb. 2008.

[6] Venmathi, M. and Ramaprabha, R.. “A Comprehensive Survey On Multiport Bidirectional Dcdc Converters For Renewable Energy Systems”, Journal of Agricultural & Biological Science, 2013

[7] Moumita Das and Vivek Agarwal, “Novel High Performance Stand Alone Solar PV System with High Gain, High Efficiency DC-DC Converter Power Stages”, DOI 10.1109/TIA.2015.2454488, IEEE.

[8] A.Chikh and A. Chandra, “Voltage and Frequency Controller for a Stand Alone PV System with Battery Storage Element”, 978-1-4673-2421-2/12/$31.00 ©2012 IEEE

[9] Modeling anYea-Kuang Chan and Jyh-ChemgGud , “Control of Stand-Alone Photovoltaic Generation System” International Conference on Power System Technology, 2010.

[10] Manuel JesúsVasalloVázquez, José Manuel AndújarMárquez, and Francisca Segura Manzano, “A Methodology for Optimizing Stand-Alone PV-System Size Using Parallel-Connected DC/DC Converters”, IEEE TRANSACTIONS ON INDUSTRIAL ELECTRONICS, VOL. 55, NO. 7, JULY 2008.

[11] H. Parmar, “Artificial Neural Network Based Modeling of Photovoltaic System”, International Journal of Latest Trends in Engineering and Technology (IJLTET), Vol. 5 Issue 1 January 2015

[12] Simon K. K. Ng, J. Zhong and John W. M. Cheng, “Probabilistic Optimal Sizing of Stand-Alone PV Systems with Modeling of Variable Solar Radiation and Load Demand”, 978-1-4673-2729-9/12/$31.00 ©2012 IEEE

APPENDIX

S/N	*Parameter Specification*	*Values*
PV Module		
1	No. of Module in Series	5
2	No. of Module in parallel	66
3	Short Circuit Current (I_{scr})	5.96A
4	Open Circuit Voltage (V_{oc})	64.2V
Boost Converter		
5	Shunt Capacitor	50µC
6	Series Indictor	5mH
PWM Inverter		
7	Snubber resistance	500Ω
8	Snubber capacitance	Inf
Battery- Acid Lead type		
9	Nominal Voltage (V)	445 V
10	Rated capacity	100mA