PV Based DC-DC Converter Design Using MPPT For Stand-Alone System

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Abstract: In photovoltaic array, a DC-DC converter plays most important role.DC-DC converter is used to obtain boosted output voltage for the solar PV module. A soft computing technique (MPPT) is required to operate this PV module. We can increase the output voltage of photovoltaic (PV) system by using the soft computing (MPPT) technique. This voltage depends upon the switching frequency and duty cycle of the converter. The paper aims to study PV system which uses a DC-DC boost converter using soft computing as the MPPT for standalone system.

Index Terms: PV, MPPT,Boost converter.

1. INTRODUCTION

In present time electrical energy plays role as an important factor for development of human colonization and economic growth of country. Due to increase in industrialization and population, there is more demand for electrical energy. Heavy consumption of electricity challenges the power generated by using non-renewal energy sources. A photovoltaic panel can be used for power generation since the solar energy is a non-conventional energy resource and has quite promising results. The initial installation cost of non-conventional generation system is very high (counting the maintenance cost also). PV modules have cells arranged inside in series and parallel as per the user's requirements. By taking each PV module in series and parallel arrangement we can meet our load demand. An ideal PV cell is modeled as current source with anti-parallel diode. This diode is the cause of non-linear characteristic of I Vs V of a PV module. Among all others, solar energy is the mostly used renewable resource owing to its availability and it supports green being an environmental friendly resource.The PV array efficiency is comparatively very less and also the solar irradiation is not constant whole day .A PV panel happens to have a unique point called as the maximum power point, which is observed to give/extract maximum power for given climatic conditions such as irradiation and temperature.The MPPT depends not only on the climatic conditions but also on the PV panel manufacturing characteristics.A soft computing control technique is required for tracking the maximum power point at which PV system operates.

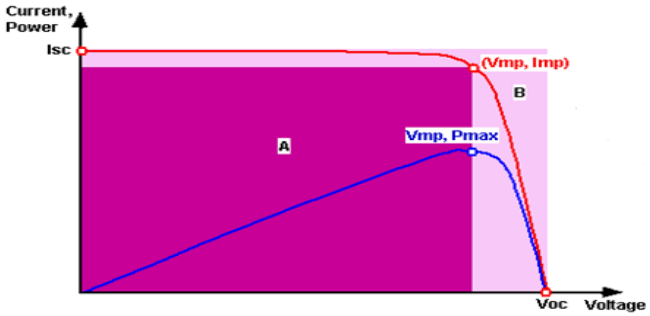

FIG.1: *I-V Characteristics of a PV Module showing maximum power point*

2. PRINCIPLE OF CONTROL

Constant voltage control method is one of the various types MPPT concepts. When the MPPT works according to the specific logic, the constant DC link voltage forms the basis for control. For other types of MPPT, the maximum power point logic has a higher priority than the constant link voltage. This is acceptable because the steady state voltage is more critical at the AC point of common coupling. By thus 'splitting' the control task, the boost converter can be 'dedicated' to MPPT altogether.

2.1 MODELLING OF SOLAR CELL

A Solar panel is formed by taking a group of solar cells together in a series or parallel fashion. In the PV cell diode is connected in parallel with the current source in reverse direction.

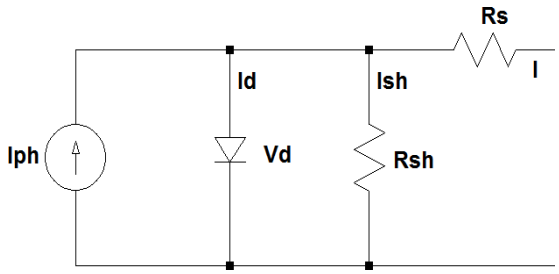

Fig. 2*. Single diode model of a solar cell*

$$I=I_{ph}-I_s[\exp((V+IR_s)q/(akTN_s))-1]-(V+IR_s)/R_{sh} \quad (1)$$

$$I_{ph}=I_r*I_{sc}/I_{r0} \quad (2)$$

$$I_s=I_{sc}/[\exp(V_{oc}/(aV_t))-1] \quad (3)$$

$$I_d=I_s*[\exp((V+IR_s)/(aV_t))-1] \quad (4)$$

$$I_{sh}=(V+IR_s)/R_{sh} \quad (5)$$

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$V_t=kTN_s/q$ (6)
$I=I_{ph}-I_d-I_{sh}$ (7)
I & V : Cell output current and voltage
I_s: Cell reverse saturation current
T:Cell temperature in Celsius
K=Boltzmann's constant
Q=electron charge
Iph=Light generated current
Rsh=Shunt resistance
Rse=Series Resistance
Experiment results shows that the current of the PV panel is depended on the resistance .The PV current varies more according to the resistance connected in series but not that depended on the shunt resistance.

3.EFFECT OF VARIATION OF SOLAR IRRADIATION

The output of PV module is dependent on temperature and solar irradiation values. With the change of solar irradiation and temperature P-V and I-V curves of solar cell changes accordingly giving variation in output curve but control mechanism like algorithms of P &O and IC methods including iterative processes can track this change and can extract maximum power available in the PV cell. In this way it caters to the need of the load demand .Higher value of solar irradiation results in increased power curve.Variation in the solar irradiation results in the variation of open circuit voltage.The open circuit voltage increases with the increase of solar irradiation.This happens when more packets of photons are incidented on the panel,thereby supplying the electrons with higher excitation energy,which increases the electron mobility and so large power generated.

3 SECTIONS

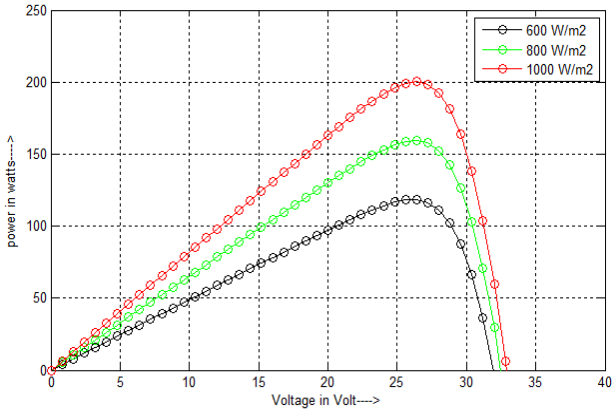

FIG.3. *P-V characteristic of Solar cell*

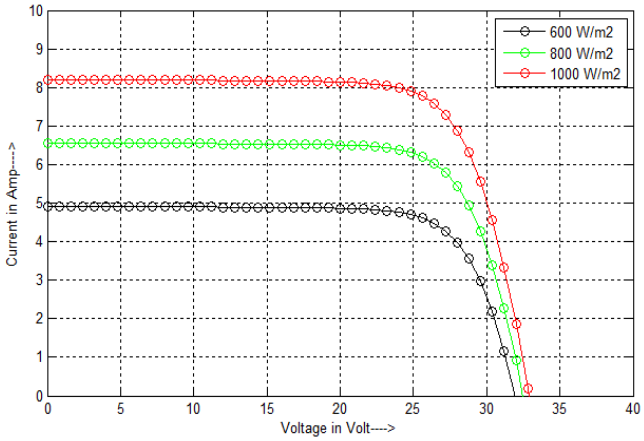

FIG.4. *V-I characteristic of Solar cell*

4.EFFECTS OF VARIATION OF TEMPERATURE

Variation in temperature directly proportional to the open circuit voltage.As the temperature increases,the output voltage increases vice-versa.

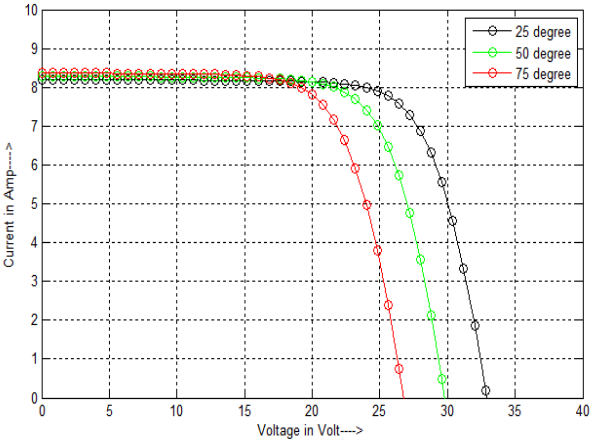

FIG-5.*Variation of I-V curve with temperature*

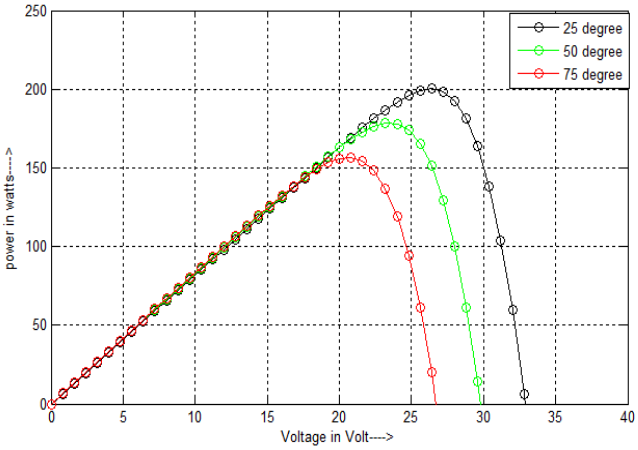

FIG-6*.Variation of P-V curve with temperature*

5.BOOST CONVERTER

This is also called step-up converter.This function of boost converter is to increase the output voltage instead of using a transformer.The boost consists of an inductor,a diode and a high frequent switch.This components with proper

arrangement;when works I co-ordination supplies power to the load at a voltage greater than the input voltage.

5.1-MODES OF OPERATION

The boost converter operates into two modes.It involves closing mode and opening mode of high frequency switch.the closing mode is charging mode of operation(when switch is off).The opening mode of operation is known as discharging mode of operation(when switch is on).

A.CHARGING MODE

Since circuits consists of a inductor connectedto a supply,the supply charges the inductor.The current in the conductor exponential in nature but for easiness in understanding and mathematical calculation,it is assumed to be linearly varying.The reverse baised mode of diode doesn't allow the flow of current from source to load.So the need of the load is catered by the discharging of the capacitor.

B.DISHARGING MODE

In the discharging mode turned on and the diode is forward biased.the inductor discharges and the source charging the capacitor,caters to the load demands.The current variation is negligible and can be neglected.In many cases the current is taken to have a constant value.

6.MAXIMUM POWER POINT TRACKING

Without the use of any MPPT method,the efficiency of the solar cell is found to be around (18-20)%,which is very low and not beneficial.Inorder to increase its efficiency ,various methods are taken.The work of this controller is load matching i.e matching the source and load properly,such method is the maximum power point tracking(MPPT).Using this technique,the maximum possible power can be found/searched from a source which is variable in nature.Since the I-V characteristic is non-linear in nature.It can be hardly used to power a certain load.When a boost converter along with a MPPT algorithm is used,this can be achieved.Here the MPPT techniqueseek the control the duty cycle of the boost converter

6.1-METHODS OF MPPT-

Till date many search methods have come into practice.Some are listed below:-

a)Perturb and Observe method
b)Incremental Conductance
c)Open Circuit voltage method
d)Short Circuit voltage method
e)Fuzzy Logic method
f)Artificial Neural Networ

Among all of these,the first two are most commonly used.

6.1.1-PERTURB AND OBSERVANCE METHOD

For the understanding of the operation of this method,we need to study it in the method of flowchart.It has continous iterative steps.The flow charts for the above said methods are shown below.The flow charts for perturb and Observe method

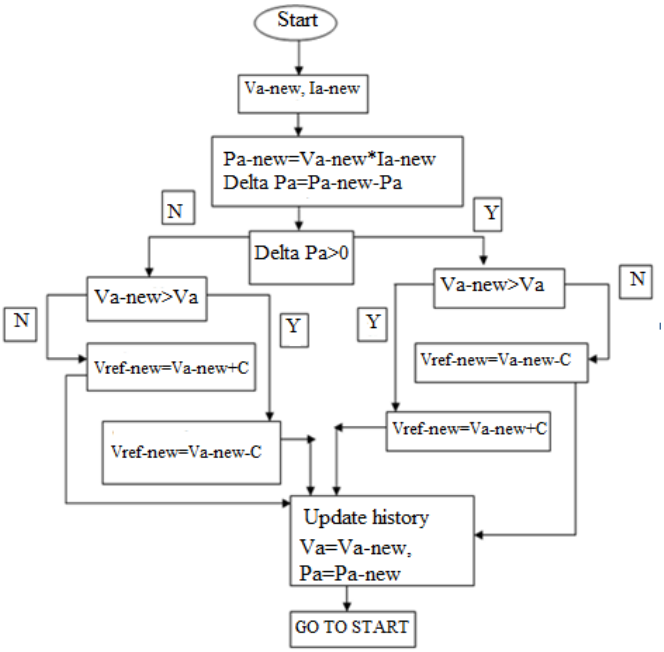

Fig-7.*Flowchart of P&O method*

6.1.2INCREMENTAL CONDUCTANCE:-

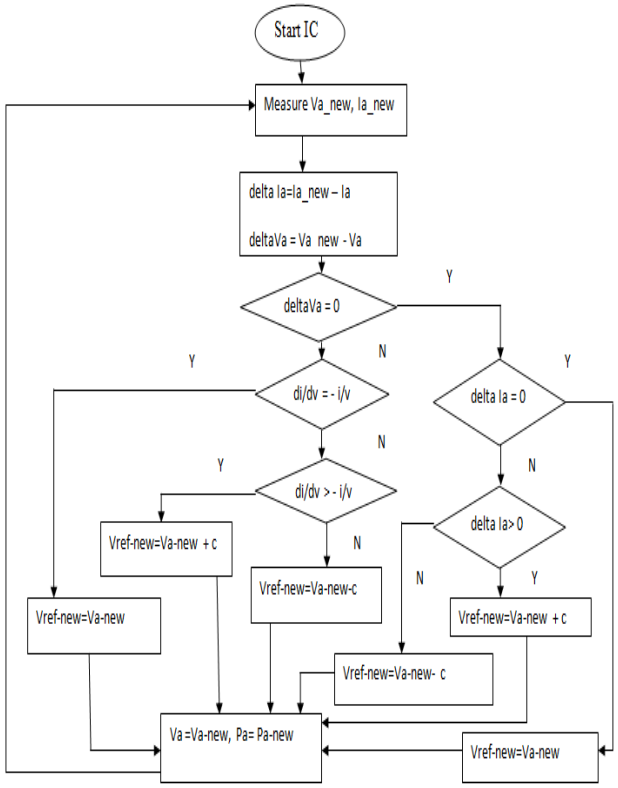

Fig-8*.Flowchart of IC method*

IC uses the derivative of power w.r.t derivative of voltage for maximum power point .At MPP point,the incremental conductance equals the instantaneous comductance whereas towards right of the MPP point the incremental conductance is less than instantaneous conductance and vice-versa.

6.1.3 THE FUZZY LOGIC CONTROLLER METHOD:-

The fuzzy logic consists of three steps:-

a)fuzzification
b)inference system
c)defuzzification

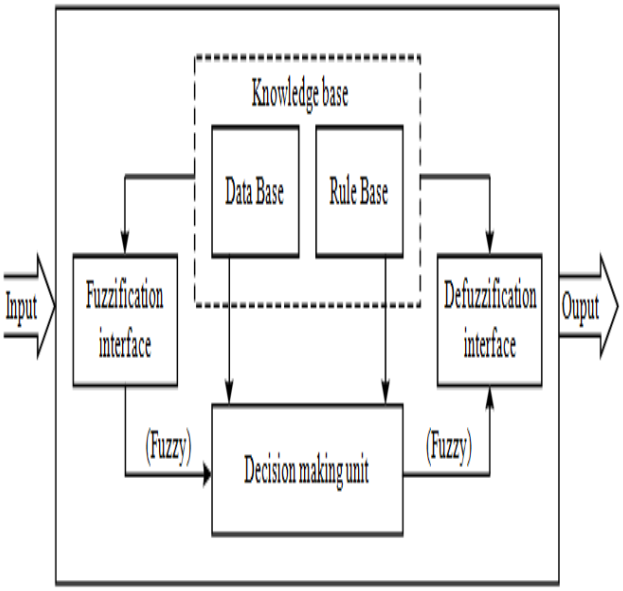

***Fig-9**.Fuzzy Logic Controller*

6.1.4-MODIFIED FUZZY LOGIC CONTROL METHOD-
This method Calculates the duty cycle of switch from the change in power and change in voltage.
ΔP=P(K)-P(K-1)
ΔV=V(K)-V(K-1)

7.SIMULATION RESULTS OF THE MODEL:

The proposed model is simulated in MATLAB/Simulink environment. Which is given in figre 10. The figure 11.1 and 11.2 shows the IV and PV curve PV system with P&O MPPT algorithm. The figure 12.1 and 12.2 shows the IV and PV curve PV system with Fuzzy MPPT algorithm. The figure 13.1 and 13.2 shows the IV and PV curve PV system with modified fuuzy MPPT algorithm.

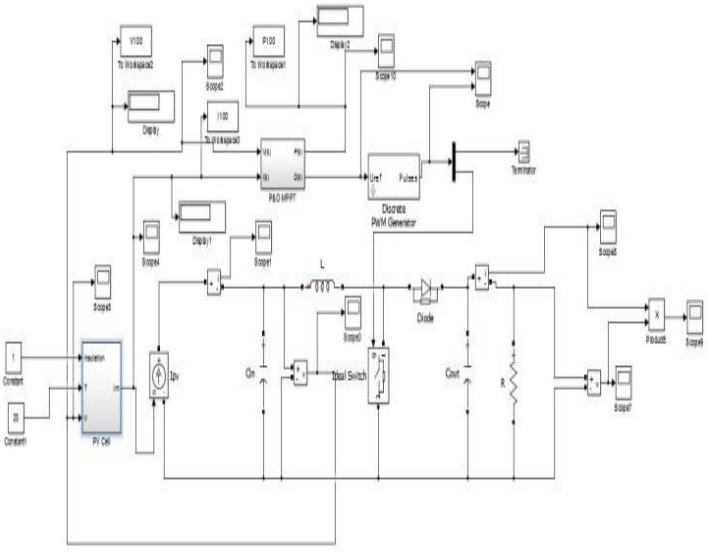

***Fig-10.**Simulation model of proposed converter*

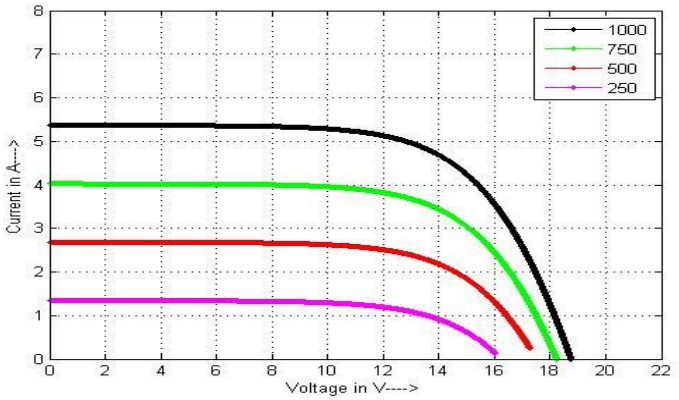

***Fig.11.1**.IV Curve of P&O MPPT Algorithm*

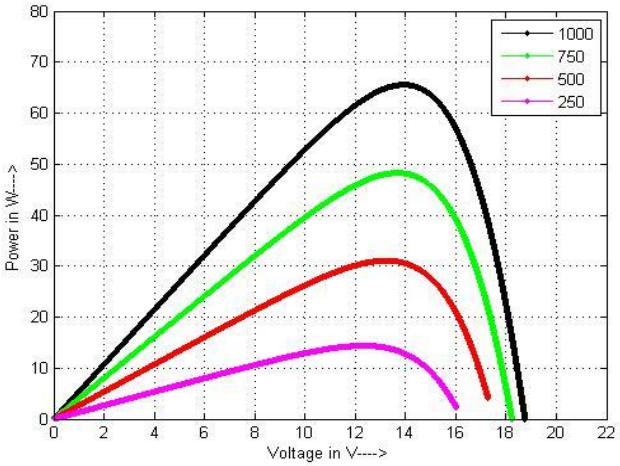

***Fig 11.3** PV Curve of P&O MPPT Algorithm*

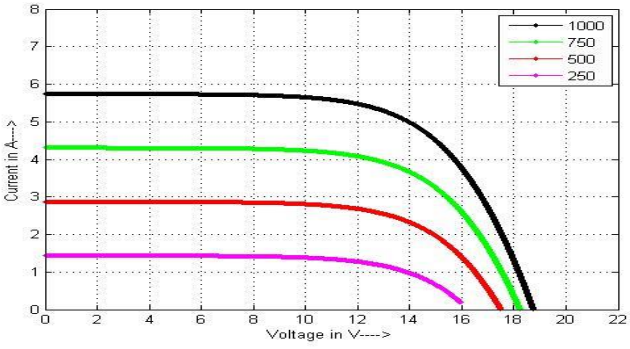

***Fig. 12.1**. IV Curve of Fuzzy Logic MPPT Algorithm*

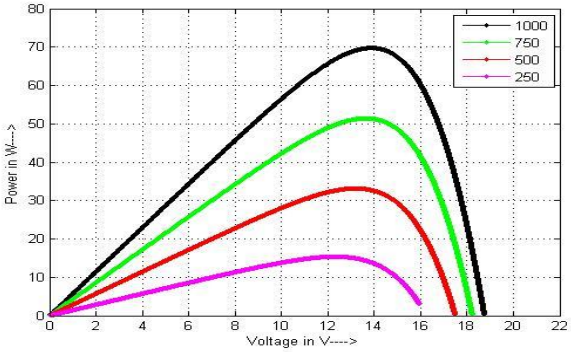

***Fig 12.**2 P-V Curve of Fuzzy logic MPPT Algorithm*

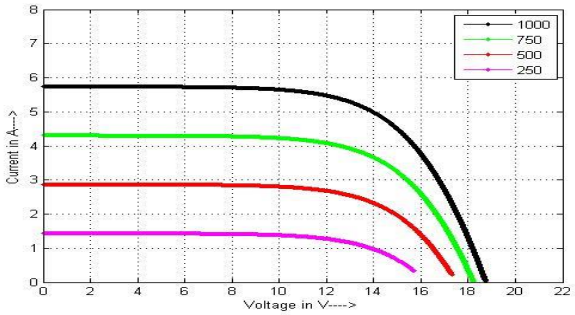

***Fig.13.1**.I-V Curve of Modified Fuzzy Logic MPPT Algorithm*

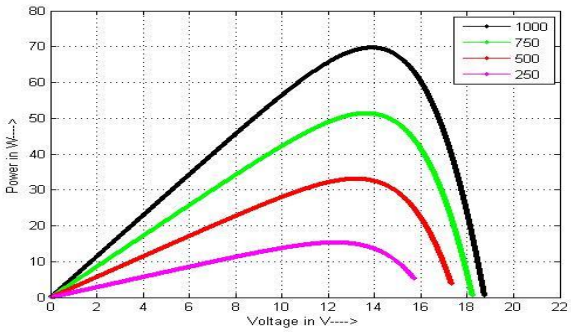

***Fig. 13.2**. PV Curve of Modified Fuzzy Logic MPPT*

***Table 1:** Comparison of all methods*

Insolation	G (W/m^2)	1000	750	500	250
P&O	P_{pv} (W)	65	50	31	14
	Tracking time (sec)	0.014	0.011	0.007	0.006
	Steady state oscillations	Very high	Very high	Very high	Very high
Fuzzy	P_{pv} (W)	70	50	30	14
	Tracking time (sec)	0.0362	0.014	0.012	0.01
	Steady state oscillations	High	High	High	High
Modified fuzzy	P_{pv} (W)	73	52	33	16
	Tracking time (sec)	0.01	0.004	0.003	0.002
	Steady state oscillations	None	None	None	None

5.CONCLUSION

Using an algorithm like P & O and IC method, this MPPT unable the Iterative process to decide its suitable duty cycle for maximum power extraction for PV panel.Without the use of MPPT there is a drastic change in the result since the user has to decide the duty cycle by hit and run method .This random selection of duty cycle is not appropriate with the change in the solar irradiation,there is a change in maximum power point,thereby changing the output voltage.Using constant duty cycle,maximum power is hardly possible which makes the system less efficient.

6.REFERENCES

[1] M. Theristis and I. Papazoglou, “Markovian reliability analysis of standalone PV systems incorporating repairs,”IEEE J.Photovolt,vol.4,no1,pp.14-422,Jan.2014”.

[2] . Ling, G. Zhao, and Q. Huang, “High step-up interleaved boost converterwith low switch voltage stress,”Electr. Power System.Res,vol.128,pp.11-18,2015.

[3] K.-C. Tseng, J.-Z. Chen, J.-T. Lin, C.-C. Huang, and T.-H. Yen, “Highstep-up interleaved forward- flyback boost converter with three-windingcoupled inductors,”IEEE Trans. Power Electron,vol.30,no.9,pp4696-4703,sep.2015”

[4] B. Mangu , S. Akshatha, , D. Suryanarayana and B. G. Fernandes “Grid-Connected PV-Wind-Battery-BasedMulti-Input Transformer-CoupledBidirectional DC-DC Converterfor Household Applications”, ieee journal of emerging andselected topics in power electronics, VOL. 4, NO. 3, SEPTEMBER 2016.

[5] Abbassi, R., Hammami, M., Saidi, S., et al.: ‘Analysis of renewable energypower systems: reliability and flexibility during unbalanced network fault’,Handb. Res. Adv. Intell. Control Eng. Autom., 2015, 1, (24), pp. 651–686, doi:10.4018/978-1-4666-7248-2.ch024.

[6] Abbassi, R., Marrouchi, S., Saidi, S., et al.: ‘Optimal energy managementstrategy and novel control approach for DPGSs under unbalanced grid faults’,J. Circuits Syst. Comput., 2019, 28, (4), pp. 1–21, doi: 10.1142/S0218126619500579.

[7] Montoya, D.G., Ramos-Paja, C.A., Giral, R.: ‘Improved design of sliding-mode controllers based on the requirements of MPPT techniques’, IEEETrans. Power Electron., 2016, 31, (1), pp. 235–247.

[8] Mamarelis, E., Petrone, G., Spagnuolo, G.: ‘Design of a sliding-mode-controlled SEPIC for PV MPPT applications’, IEEE Trans. Ind. Electron.,2014, 61, (7), pp. 3387–339.

[9] Kchaou, A., Naamane, A., Koubaa, Y., et al.: ‘Second order sliding mode-based MPPT control for photovoltaic applications’, Solar Energy, Elsevier,2017, 155, (2017), pp. 758–769.

[10] Rajeswari, P., Bidyadhar, S.: ‘Double integral sliding mode MPPT control ofa photovoltaic system’, IEEE Trans. Control Syst. Technol., 2016, 24, (1), pp.285–292.

[11] Bojoi, R.I., Limongi, L.R., Roiu, D., et al.: ‘Enhanced power quality controlstrategy for single-phase inverters in distributed generation systems’, IEEETrans. Power Electron., 2011, 26, (3), pp. 798–806.

[12] Babita Panda, Dr.Bhagabat Panda, Dr.P.K Hota “A comparative analysis of PWM methods of ZSI used for PV system”, Proceedings of the 5th International Conference on Frontiers in Intelligent Computing: Theory and Applications FICTA 2016, Volume 1, Page No.281-291, 16-17 September 2016, KIIT University, Bhubaneswar.

[13] Babita Panda, Akashdeep Sarkar, Bhagabat Panda, Dr.P.K Hota, “A Comparative Study of PI and Fuzzy Controllers for Solar powered DC-DC Boost Converter” International Conference on Computational Intelligence and Networks (CINE), Bhubaneshwar, 2015, pp. 47-51.

[14] Babita Panda, Dr. P. K. Hota and Dr.Bhagabat Panda “Fault Analysis of Grid Connected Photovoltaic System” American Journal of Electrical Power and Energy system,Vol.5,Issue 4,July 2016,pp 35-44.

[15] Babita Panda, Dr. P. K. Hota and Dr.Bhagabat Panda “A simple current control strategy for single stage grid connected Three-phase PV Inverter” American Journal of Electrical and Electronic Engineering, 2016, Vol. 4, No. 4, pp-102-109.