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Modeling and Simulation of Photovoltaic with Fuzzy and Power Management of Hybrid System

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ABSTRACT: Renewable energy sources (RES) have been one of the best alternative to ensure reliable energy source as it omnipresent free of cost and causes minimum environmental concerns. Among available renewable sources, photovoltaic (PV) generation, integrated with power backup storage unit, has been optimal choice for isolated loads. This paper deals with PV generation unit integrated with battery storage unit (BSU), conversion unit, and maximum power point tracking (MPPT) unit. MPPT technique used in this paper includes incremental conductance topology and fuzzy approach. Power interfacing unit includes power electronic converter like buck boost and multilevel inverter with a new topology to reduce the harmonics, ripple in dc which is a major problem to isolated generation due to uncertain availability of power source.

KEYWORDS*:* fuzzy logic, buck boost converter, MPPT, PV, hybrid power system

I. INTRODUCTION

Due to depleting conventional energy sources and increasing environmental concerns, RES like solar, wind, tidal etc., has gained more attention in the last few decades as alternate sources of energy. Fossil fuel has limited reserve and need very long time to restore once depleted. It also causes environmental concerns like increasing carbon emission, global warming and acid rain around the globe. Among the RES PV is widely used as isolated unit and it has a great advantage that it can be used in small scale like house hold application, data commutation & tele-commutation centre, electrical air-craft's & in agricultural purpose.

From the above view point, PV system experiences as many advantage in a large scale but its output power is variable, weather condition is major problem, which give rise to the problem of constant output power due to secondary battery is consider. Over the past decade, RES shows the robust and continuous growth 68.90% of energy in India is coming from the wind, while the PV contributed nearly 4.59% of the renewable energy install capacity in India. At the end of December 2014

Total install capacity is shown by-

Table-I

Sources	Total install capacity (MV)
Wind power	22,465.03
Solar power	3,062.68
Small hydro power	3,590.83
Biomass power	2,800.35

If we consider the solar 20,000 MV grid based solar power and 2000 MV off grid solar power is there. In India highest capacity solar park is in MP &Rajasthan has a capacity to give nearly 2100GW of energy. Pie chart showing the install capacity of RES given by MNRE. PV system has main disadvantage that is supply is interrupt with weather condition, so to overcome this problem, integrate PV power system is design, that include the diesel generator, superconductive

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magnetic energy storage (SMES), battery storage system and fuel cell system. The diesel back-up for the PV power system is able to continue the power supply up to 24 hours but it has a drawback of the environment condition. The SMES technology give rise but it has a problem of the health risk due to the strong magnetic field. Among the integrated PV power system, secondary battery topology is very attractive and intermittent sources of generation because of higher efficiency modularity and fuel flexibility.

A rapid increase in the load power or low temperature would result in a significant drop in the fuel cell output voltage, which can deteriorate the power quality or even shut down of the power system. To increase the peak capacity the secondary battery are used. These battery storage the energy and give the power when there is heavy load and system is not able to provide the continuous power. Thus secondary battery is able to control the uninterrupted high quality power. Solar power sources are very difficult to operate as a base load plant, they are not be capable to provide the continuous power for a long period as they are affected by the several environmental condition using them in peak load gives the economic benefits because they can start, synchrouns the plant quickly and give the quick response to the load. The hydro power plant can be used as both base and peak load condition; thermal & nuclear are suitable for base load and gas solar, wind secondary battery are very suitable for peak load operation.

Given below a load graph from the graph we can study that the in between 10am to 6 pm load is maximum in this we can use the peak load plant. From all above consideration we can get economical hybrid system benefit load graph is showing below

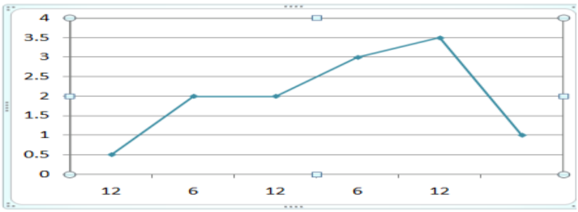

Fig 1-load graph

The objective of this study is to design an effective power management system for pv/fuel cell/battery hybrid power system so that the combination can be used as reliable power sources. In the following the structure of the hybrid power is first described and the control strategies for power management of the hybrid system are discussed. The simulation of solar PV is given.

II. STRUCTURE OF HYBRID SYSTEM

The hybrid power system consists of PV array, fuel cell, battery which is connected to the dc voltage bus as shown in fig. There are two main sources of energy PV panel and secondary battery is the secondary option of the energy storage devices and it can provide the power when rated the demand is more than the rat Inverter is connected for the conversion of ac-dc after inverter conversion it can be applied to the commercial or industrial purpose[1-3].

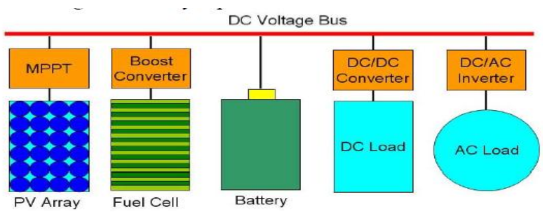

Fig 2- Hybrid system

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The PV panel provides as much power as possible to the load. The function of the secondary battery is to supply to the load the rest of the average power that the PV panel can not meet. The power conditioning system (including power converters and associated control electronics) controls the power flowing from each source of energy, and allocates the available power to recharge the battery if possible[4].

III. MULTI-LEVEL INVERTER

We have a another innovative mythology that is multi level inverter which is connected in the string of PV panel, which conclude the some advantages that is-

1. Less harmonic.
2. Minor fault will not damage whole system
3. Reduced switch confrigation can be adopted

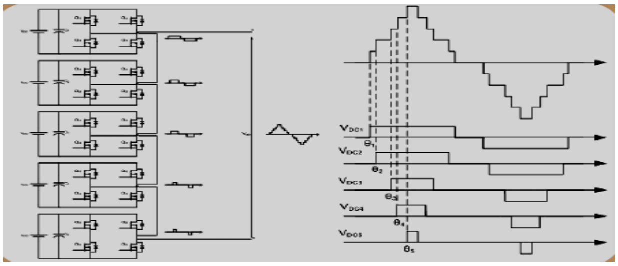

Fig 3-Multi level inverter with chopped waveform

IV. SOLAR PANEL

Photo voltaic panels are interfaced with the primary energy.

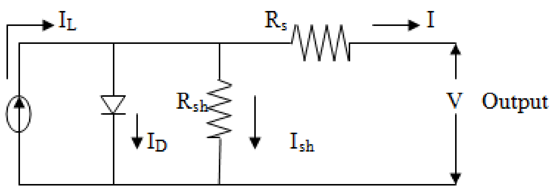

Fig 4-circuit model of single diode PV module

One of the most popular models is the equivalent circuit with single diode as shown in fig 1.It is shown as a current source(IL), Shunt Diode(D), Parallel resistor(RP) and a series resistor Rs. When the cell is operated at open circuit, I = 0, the voltage across the output terminals is defined as the open-circuit voltage. Assuming the shunt resistance is high enough to neglect the final term of the characteristic equation, the open-circuit voltage VOC is-

$$I_{pu} = N_p * I_{pn} - N_p * I_o \left[exp * \left\{ q * \frac{(V_{pv} + I_{pv} * R_s)}{N_s AKT} \right\} - 1 \right]$$

ForthePVoutputcurrent

Photo Current

$$I_{ph} = [I_{sc} + K_i[T - T_r]] * \frac{S}{1000}$$

Open ckt. Voltage

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$$VOC = \frac{KT}{Q} LN\left(\left(\frac{IL}{IO}\right) + 1\right)$$

Similarly, when the cell is operated at short circuit, V = 0, the current I through the terminals is defined as the short-circuit current. It can be shown that for a high-quality solar cell (low RS, I0 and high RSH) the short – circuit current ISC is equal.

V. MPPT TECHNIQUES

Numerous techniques have been proposed so far to realize MPP. These MPPT methods vary in complexity, sensors required, convergence speed, cost, range of effectiveness, implementation hardware, popularity, and in other respects. Among them constant voltage method, the Perturb-and Observe (***P&O***) method, the incremental conductance method etc are most common. Incremental Conductance has the same measurement parameters as ***P&O*** method However, from derivation of this method, it can be seen that it has no consideration about change of temperature. In a nutshell, in the fast convergence environment these conventional ***MPPT*** methods face a great deal of difficulty to track the actual ***MPP***. So, the fuzzy logic control method is very efficient [5-9].

VI. INCREMENTAL CONDUCTANCE

The incremental conductance (IncCond) method is based on the fact that the slope of the PV array power curve (Fig.) is zero at the MPP, positive on the left of the MPP, and negative on the right, as given by $dP/dV = 0$, at MPP $dP/dV > 0$, left of MPP $dP/dV < 0$, right of MPP $\Delta I/\Delta V = -I/V$, at MPP $\Delta I/\Delta V > -I/V$, left of MPP $\Delta I/\Delta V < -I/V$, right of MPP.

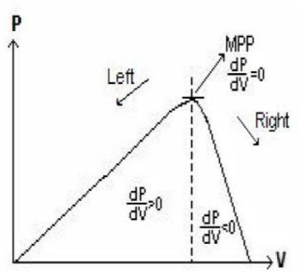

Fig 5- p-v graph showing Inc method

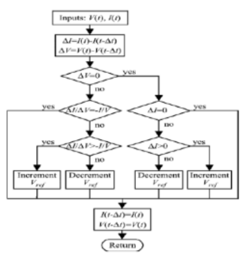

Fig 6 —flow chart of inc. conductance

The MPP can thus be tracked by comparing the instantaneous conductance (I/V) to the incremental conductance ($\Delta I/\Delta V$) *as* shown in the flowchart in Fig. *Vref* is the reference voltage at which the PV array is forced to operate. At the MPP, *Vref* equals to *VMPP*. Once the MPP is reached, the operation of the PV array is maintained at this point unless a change in ΔI is noted, indicating a change in atmospheric conditions and the MPP. The algorithm decrements or increments *Vref* to track the new MPP.

VII. FUZZY LOGIC CONTROL

Microcontrollers have made using fuzzy logic control popular for MPPT over the last decade. As mentioned in, fuzzy logic controllers have the advantages of working with imprecise inputs, not needing an accurate mathematical model, and handling non linearity. Fuzzy logic control generally consists of three stages: fuzzification, rule base table lookup, and defuzzification. During fuzzification, numerical input variables are converted into linguistic variables based on a membership function similar to Fig. In this case, five fuzzy levels are used: NB (negative big), NS (negative small), ZE (zero), PS (positive small), and PB (positive big).

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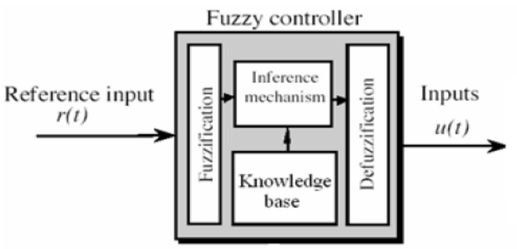


Fig 7 - fuzzy method

VIII. SIMULATION CIRCUIT OF PV PANEL

A model of PV module which includes photocurrent source, the saturation current of the diode and a series resistance is considered based on the Scotty diode equation. The block diagram of the solar panel is shown. The inputs to the solar PV panel due to high temperature inversely proportionality to the voltage, solar irradiation or solar insolation proportionality to the current. The number of solar cells in series increases the voltage and number of rows of solar cells in parallel increase the current of the device [10].

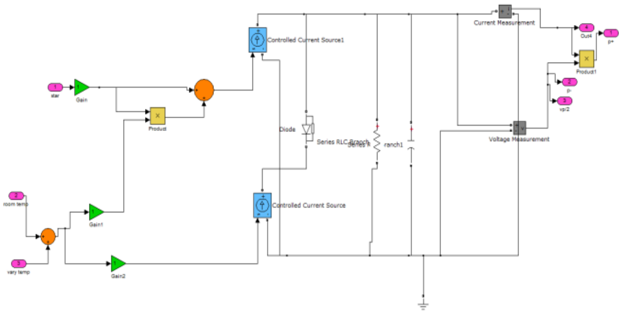
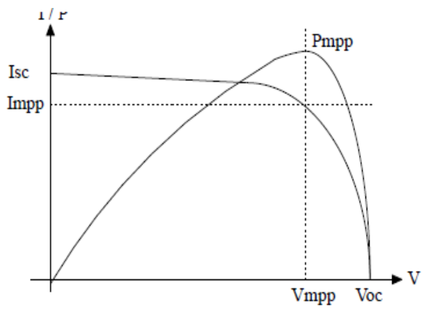


Fig 8- simulation of single diode PV module

Fig 9- PV module

P-V/I-V Ch.



Maximum power point (Vmp, Imp).

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IX. MEMBERSHIP FUNCTION

The input variables to the FLC are the Error (E) and Change of Error (CE) whereas the output of FLC is the duty cycle (D). The set of the first input variable (E) is transformed in terms of its linguistic variable by using five fuzzy subsets which are denoted by NB (negative big), NS (negative small), ZE (zero), PS (positive small) and PB. The membership functions for the variables are shown in Figure [11-15]

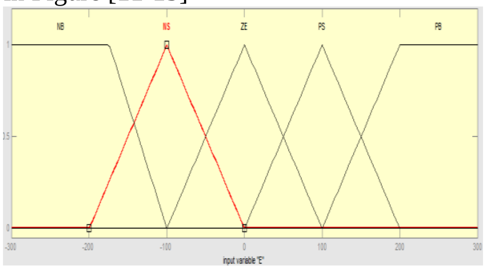

Fig 10- Membership Functions For Input Variable 'E'

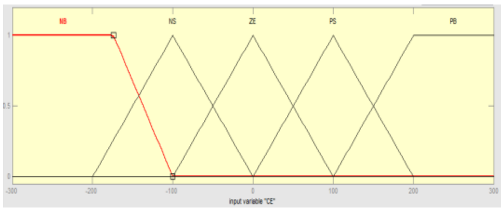

Fig 11- Membership Functions for Input Variable 'CE'

The set of the second input variable (CE) which is classified into five fuzzy subsets which are denoted by NB (negative big),NS (negative small), ZE (zero), PS (positive small) and PB (positive big)[15-19]. The membership functions for the variables are shown in figure6. The justification subset for the output variable, D is depicted in Figure

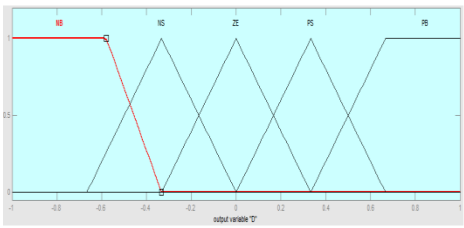

Fig 12- Membership functions for output variable 'D'

FUZZY RULES FOR MPPT

Table 2 Rules Table

CE \ E	NB	NS	ZE	PS	PB
NB	NB	NB	NB	NS	NS
NS	NB	NS	NS	NS	PS
ZE	NB	NS	ZE	PS	PB
PS	NS	PS	PS	PS	PB
PB	PS	PS	PB	PB	PB

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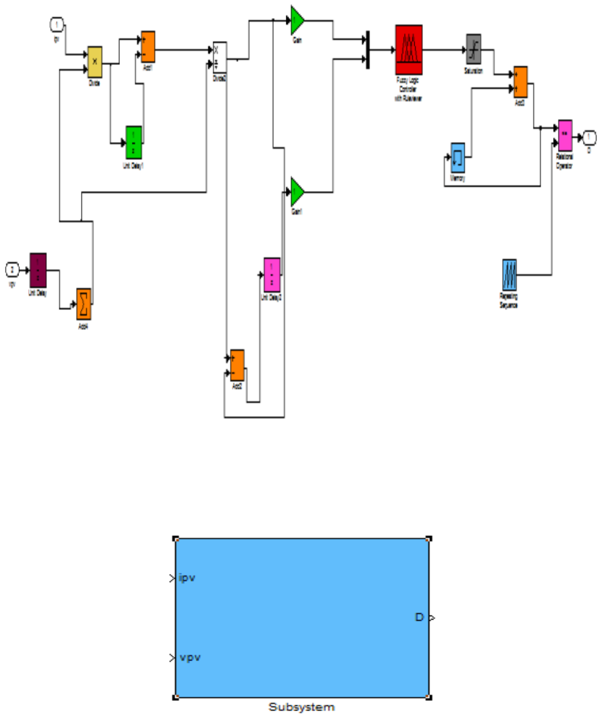
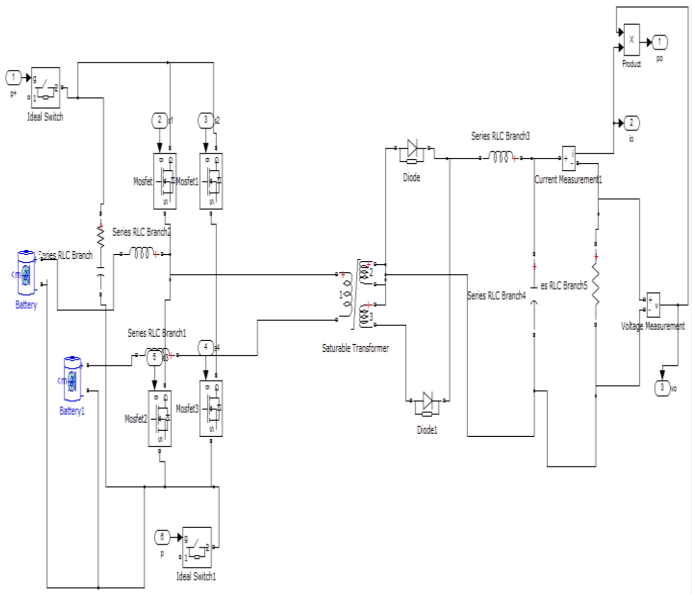


Fig13- simulation fuzzy controller

X. CONVERTER DESIGN

A parallel combination of several individual buck boost converter is combined for multiport dc/dc conversion system.



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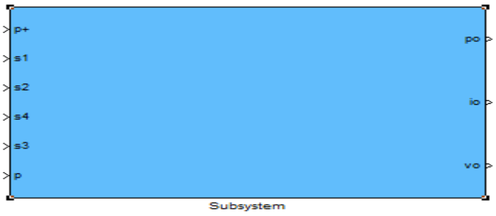

Fig14- simulation of converter

In the given fig, the simulation ckt of four port converter is shown and in fig fuzzy based MPPT algo is shown. The input port of the pv module are the solar irrandance and ambinent temp.
Parameter of the given simulation is given below-
Inductance L1,L2= 0.01
Capacitance = 2e-3
Load resistance= 500 ohm
Input=100v
By using the converter the output voltage is reduced using the interleaved converter it is reduced upto 0.03%

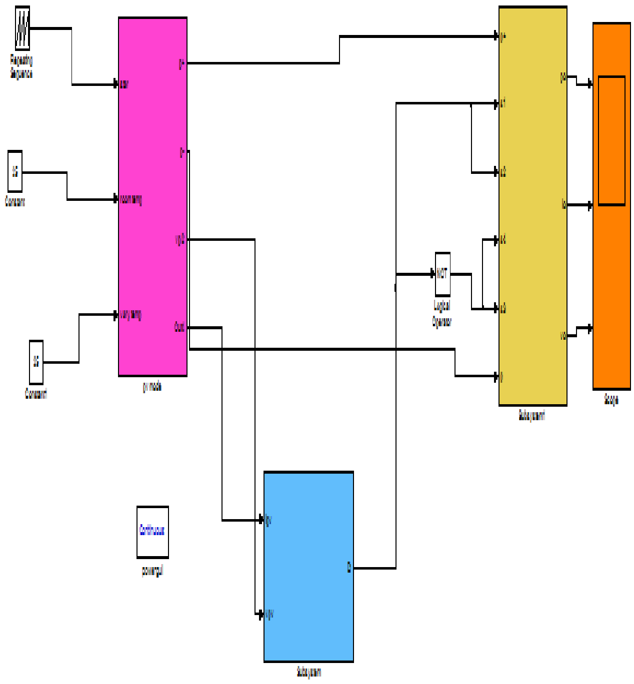

Fig15- simulation of PV with fuzzy controller

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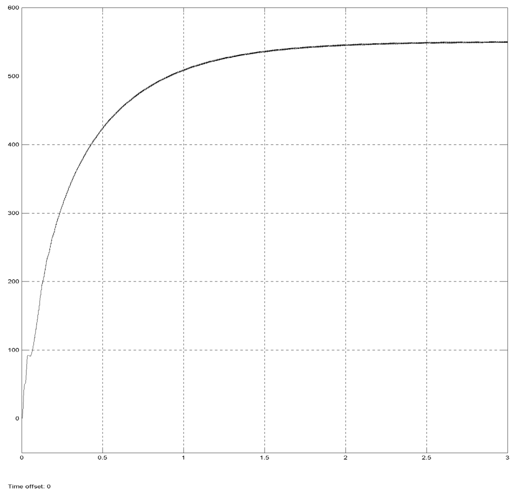

Fig15- simulation of PV with fuzzy controller

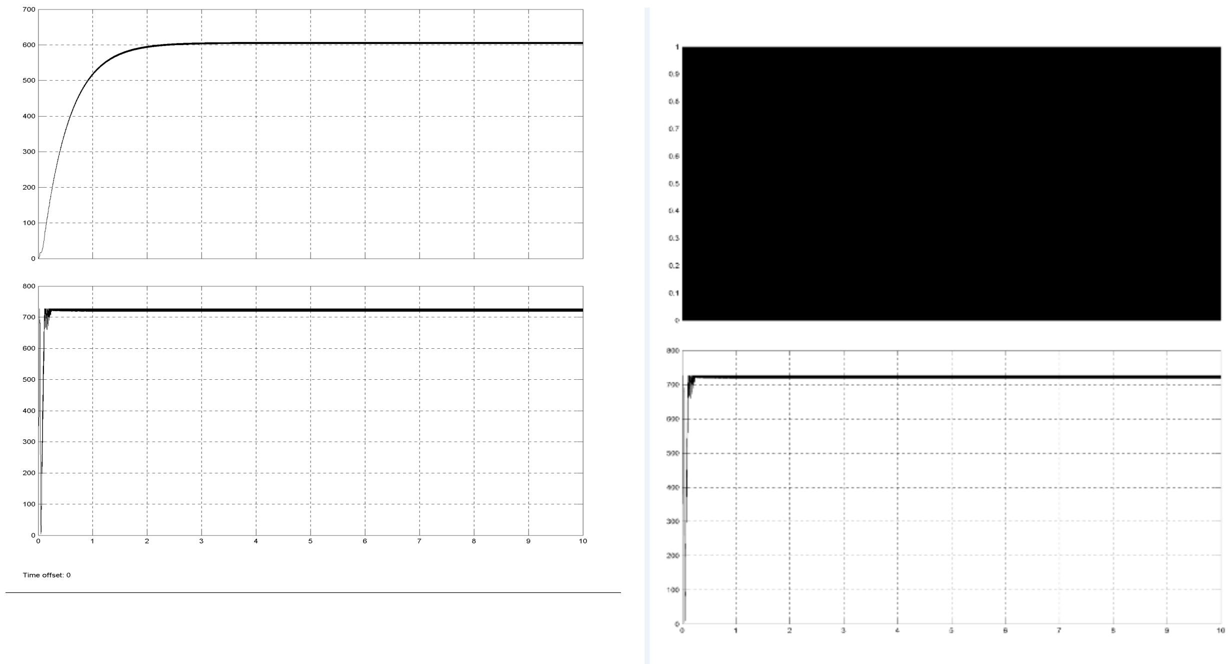

Fig16- output wave from

XI. CONCLUSION

Topology of hybrid syestem with PV and secondary battery has been study.simulation with fuzzy has been done and output voltage ripple has reduced ,with the fuzzy complexity has reduced and it can be used in pv plant,solar pumping etc.

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REFERENCES

[1] A.Al-Atrash, F.Tian, and I.Batarseh, ―Tri-modal half bridge converter topology for three port interface‘IEEE Transactions on power electronics‖, Vol.22, No.1, pp: 341-345, Jan 2007.
[2] A.Khaligh, J.Cao, and Y.J.Lee, ―Multiple input dc-dc converter topologies, ‖IEEE Ttransactions, power electronics‖, Vol.24, No.3, pp: 862-868, March.2009.
[3] A.Kwasinski, ―Identification of feasible topologies for multiple input dc-dc converters‖, IEEE Transactions on Power Electronics‖, Vol. 24, No. 3, pp: 856-861, March 2009.
[4]AsifulIslam,A.B.Talukdar,ohammad,P.K.Shadhukhan―Maxim um power point tracking of photo voltaic arrays in MATLAB using fuzzy logic controller‖, Annual IEEE India conference 2010 .
[5] Belaidi, Fathi, A.Haddouche, A.Chikouche, G.Mohand Kaci and Z.Smara, ―Study and simulation of a MPPT controller based on fuzzy logic controller for PV system‖, IGEC-VI-2011-208 2011.
[6] Chi K. Tse, Martin H.L.Chow ―Theoretical study of switching power converters with power factor correction and output regulation‖, Vol. 47, No 7 pp. 1047-1055, 2000.
[7] Chuanhong Zhao, Simon D.Round and Johann W.Kolar ―An isolated three port bidirectional DC converter‖ Vol 23, No 5, pp.2443 -2453, 2008.
[8] C.Zhao, S.D.Round and J.W.Kolar, ―An isolated three port bidirectional DC-DC converter with decoupled power flow management‖, IEEE Tr. Power Electron, Vol.25, No.5, pp 2443-2453.
[9] D.G.Dobbs and P.L.Chapman, ―A Multiple Input DC-DC Converter topology, ‘IEEE Transactions on Power Electronics‖, Vol. 1, No. 1, and pp: 6-9, Mar.2003.
[10] Haimin Tao, Andrwkotsopoulos, Jorge L.Duarte and Marcel A.M.Hendrix ―Transformer coupled multiport bidirectional DC- DC converter‖, Vol 26, No 6, pp.838—852, 2008.
[11] H.Tao, J.L.Duarte and M.A.M.Hendrix ―Three port Triple half bridge bidirectional converter with zero voltage switching‖, IEEE Transactions on Power Electronics, Vol. 23, No. 2, and pp: 782-792, Mar 2008.
[12] Mummadi Veerachary, Tomonobu Senjyu and Katsumi Uezato ―Neural network based maximum power point tracking of coupled inductor interleaved boost converter supplied PV system using fuzzy controller‖, IEEE Transactions on Industrial Electronics, Vol. 50, No. 4, pp: 749-758, 2003.
[13] Nichololas D.Benavides and Patrick L.Chapman ―Power budgeting of a Multiple-input buck boost converter‖ Vol .20, No 6, pp: 1303-1309, 2006.
[14] Q.Li and P.Wolfs, ―A review of the single phase photo voltaic module integrated converter topologies with three different DC link configurations‖, IEEE Trans. Power Electron., Vol. 23, No. 3, pp: 1320-1333, May 2008.
[15] Seyezhai and Mathur Analysis, design and experimentation of interleaved boost converter for fuel cell power source‘, International Journal of Research and Reviews in information sciences, Vol. 1, No. 2, pp: 62 -66 2011.
[16] Wei jiang, Babak Fahimi, ‗Multiport power electronic Interface-concept modeling, and Design, ‘Vol.26, No 7, pp 1890-1900, 2011.
[17] Wuhua Li, Jianguo XIAO, Yi Zhao and Xiangning He ―PWM plus Phase Angle Shift (PPAS) Control for combined multiport DC-DC Converters,‖ IEEE Trans. Power Electron, Vol .27, No.3, pp1479-1489, Mar 2012.
[18] Y.C.Liu and Y.M.Chen ―A systematic approach to synthesizing multiple input DC-DC converters,‖ IEEE Trans. Power Electron, Vol .24, No 1 pp .116-127, Jan.2009.
[19] Y.Li, X.Ruan, D.Yang, F.Liu and C.K.Tse ―Synthesis of multiple input DC- DC converters,‘ IEEE Transactions, power electronics,‖Vol.25, no.9, pp.2372-2385,Jan.2009
[20] Zhijun qian,Osama Abdel-rahman, Husam Al-Atrash and Issa Batarseh ―The control strategy and power management for an integrated three port converter‖ , Vol . 20, No 6, pp645-668, 2010.