PV-Hess Based Zeta Converter for BLDC Motor Drive using Fuzzy Logic Controller

P. Roja Ramani, Sheik Mahaboob Shariff, M. N. V. Venkata Brahmam

Abstract: ***The growing importance of non conventional energy in the auto mobile industry needs the use of brushless DC (BLDC) motor drives the solar photo voltaic (PV). To overcome the disadvantages in the conservative DC-DC converters, Zeta converter is used to optimize power handling through controlling of duty cycle. To mitigate changes in output of PV, the Hybrid Energy Storage System (HESS) is implemented into the PV system to maintain a constant voltage at the BLDC motor input.***

The PV-HESS system is controlled correctly by a robust power management algorithm. The Zeta converter can meet the smooth performance of the system by using particle swarm optimization technique of maximum power point tracking. By placing set of rules in the FLC controller we get the system stability faster than existed controller. The performance of the fuzzy logic controller built was demonstrated in terms of atmospheric condition changes using MATLAB/ Simulink.

Keywords: Fuzzy logic controller(FLC) Brushless DC (BLDC) motor, Photovoltaic (PV) system, Zeta converter, Particle swarm optimization (PSO).

I. INTRODUCTION

The increase in electricity demand in the 21st century has aroused scholars' curiosity about the efficient use of nonconventional energy. Solar is the available of existing non conventional energy sources because it is clean and environmentally free. Solar energy is the energy that is available from the sun in abundance. Solar power is the conversion of sunlight into electricity. As electricity plays a key role in our day today life we need it in abundance, as sunlight is clean, and is available for free solar power is created from it. Thus the heat collected by the receiver is used as electricity for performing various activities Because solar is recurrent, it is necessary towards tracking maximum power point stoic for greater efficiency of the solar system. To track the maximum power from solar PV systems so many MPPT techniques are given.Therefore, Maximum power point tracking (MPPT) is an important part of a photovoltaic (PV) systems, to provide that the power converter (MPP) at
the maximum power point operation of the solar array. [1] has all kinds of MPPT algorithm has been developed perturb
kinds of MPPT algorithm has been developed perturb observer (P & O). P & O in the process, the voltage is increased or decreased to achieve the MPP direction fixed steps. This continuous process is repeated regularly, up to MPP is reached.P and O methods are a widely used MPPT method .There are so many recent attempts to improve MPPT technologies [2] to minimize the drawbacks of conventional algorithms Due to shadows of clouds, trees, and buildings, uneven solar insulation of photovoltaic arrays is considered local shadow conditions (PSCs). PSC can cause multiple spikes in the PV feature. Traditional MPPT algorithms may bind to local peaks, whereas local peaks can not be correct MPP of the P-V feature. PSO-based MPPT algorithms[3] are unique of the enhanced and active MPPT technologies used to optimize maximum power extraction from solar PV systems and to track global MPP excitation with multiple peaks.

To provide continues supply Solar PV sources need backup, such as energy storage systems, hybrid energy storage systems are now the most popular system, This is a consolidation of batteries and super capacitors. A power backup in steady state is available via the battery, where acts as a backup for transient situations as a super capacitor. The HESS May Be Charged Or Discharged Via A Two-Way Dc-Dc Converter. Based on correct power management algorithm, a two-way DC-DC converter switching pulse may be created. Buck-Boost-type bidirectional converters have traditionally been used for this purpose.

Use a DC-DC converter to increase the voltage of the PV source. Several DC-DC converter topologies are available in the literature, where the Zeta converter captures. The researchers looked at improvements in a variety of applications, such as MPPT, Power Factor Correction (PFC), and Power Quality. The different advantages of using the zeta converter are that the infinite area of the MPPT enables dun, such as the presence of the monasterynal buck and boost converters[7], the presence of the inductor at the output end, which enables the output current to be continuous and For Zeta converters, no ripple-free c) negative voltage sensing element is not required because it produces a non-inverted output voltage. Employment of Zeta converter in brush less dc motor drive.It is good for soft start [8]and effective drive system. In the work, an effective and independent drive system is proposed, that is, the Use of PSO-based MPPT algorithm to develop switching pulses for Zeta converters, and dual-loop power management algorithm to control the overall PV HES system.

II. BLOCK DIAGRAM

The PV-HESS Power BLDC drive uses a MPPT algorithm, with the Zeta -converter engaged in Fig 1.
Solar PV systems are the primary basis for BLDC drives and energy storage system may be used as a backup to deal with intermittent conditions because of changes in environment circumstances. The change of the Zeta-converter is arranged by the triggering pulses developed by the controller.

Revised Manuscript Received on January 05, 2020.

***** Correspondence Author

Pudi Roja Ramani*, Department of EEE, Pragati Engineering College, Surampalem, India. E-mail: rojaramani333@gmail.com

Sheik Mahaboob Shariff, Associate Professor, Department of EEE, Pragati Engineering College, Surampalem, India.
E-mail: shariff.s@pragati.ac.in

M. N. V. Venkata Brahmam, Associate Professor, Department of EEE, Pragati Engineering College, Surampalem, India.
E-mail: brahmam.m@pragati.ac.in

The managing power control of system can be performed by the battery and super capacitor under different atmospheric conditions. The battery will control power changes when system is in stable state, where the super capacitor can be operate in transient conditions.

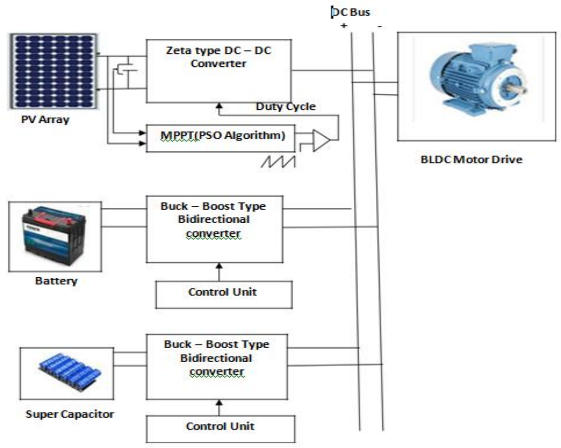


Fig.1. Hybrid PV-ESS fed BLDC motor drive

$$P_M = P_{PV} + P_{SC} + P_B \qquad (1)$$

The explicit goal is to preserve a continuous voltage on BLDC motor under different environmental change, as achieved by appropriate power controlling algorithms. The power equilibrium ratio will be the same as the power generated by the PPV in the solar arrangement; PM is a control supply driven by a motor driver; PB and PSC are the power of battery and super capacitor correspondingly.

Design and operation of zeta converter

The Zeta converter can increase or decrease the production voltage by making a suitable switch, such as the step up and step down converter. Distinct Buck-up converters, it produce a non-inverted output voltage that eliminates negative voltage sensors. Figure 2 indicates the circuit picture of the Zeta-converter.

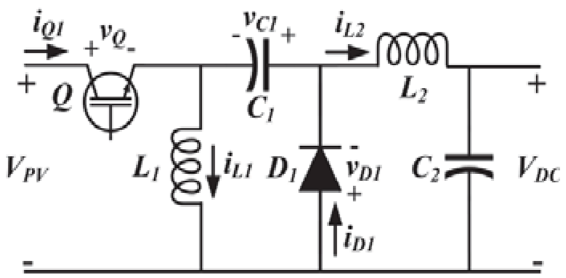


Fig.2. Zeta converter topology

Zeta- converter having semiconductor power *switch Q*, dipole *sub-D1,* AC coupling *capacity C1*, coupling inducer *1, 2 and* electronic *output c2.* Table 1 recapitulates the design parameters of the Zeta inverter. When the *q* switch is on, the operation is saved to this *mode*, when the *q* switch is disabled 1, the stored operation is discharged in capacitor *C1*, D/d inductor Generate sits in the socket for stored energy. C2 *DC connection capacitors* will be tabbed according to motor speed and the best value should be in the middle of C2min and C2 ratings.

Table I

Parameter	Expression	Selected value
Duty cycle(D)	$D = \frac{V_{OC}}{V_{OC} + V_{PV}}$ (2)	0.76
Inductor(L_1=L_2)	$L_1 = L_2 = \frac{DV_{PV}}{f_{sw}\Delta I_L}$ (3)	6Mh
Capacitor(C_1)	$C_1 = \frac{DI_{DC}}{f_{SW}\Delta V_{C2}}$ (4)	20μF
Dc link capacitor(C_2)	$C_{2min} = \frac{I_{DC}}{6 * W_{min} * \Delta V_{DC}}$ (5) $C_{2rated} = \frac{I_{DC}}{6 * W_{rated} * \Delta V_{DC}}$ (6)	850μF

III. EXISTING METHOD CONTROL STRATEGIES

In this work, The control off the DC_DC power converter plays critical part in effective BLDC drive. The Zeta converter is controlled using the PSO_MPPT algorithm for taking extreme power photovoltaic systems, while the DC_DC bi-directional converter may be controlled by dual-loop power administration policy.

PSO algorithm and application in MPP tracking

PSO has the large extent of application in power system problem optimization, engineering application, power converter harmonic reduction[13] and so on. Similar biological evolutionary algorithms, such as genetic algorithms and colonial optimization, require more parameter calculations. However, PSO is ease to implement and takes low time than the organic evolution algorithm.

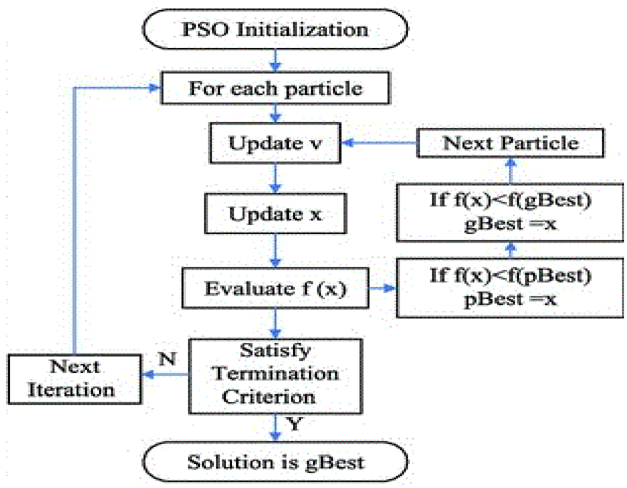


Fig.3. Flowchart of PSO-MPPT algorithm

Particles of PSO move in problem area to find a greatest solution to store in memory. Best adaptability in the overall and throughout the iteration is called the best value for individuals and the best value for the world. Each particle moves at certain speed to the personal and global best value, and changes it next every iteration. The speed and area of the first particle in d-dimensional are given below

$$\emptyset_{id}(k+1) = \emptyset_{ij}(k) + c_1 r_1 [P_{bij}(k) - P_{ij}(k)] + c_2 r_2 [P_{gi}(k) - P_{ij}(K)$$
$$P_{ij}(k+1) = P_{ij}(k) + \emptyset_{ij}(k+1) \quad (7)$$

Whereas i is 1, 2..,n;j is 1, 2, ..., d;k is no. of iterations, the k-1 index represents the next repetition. The quickening coefficient s(both represented in this article) corresponding to the personality weight and the social weight, respectively, is the uniform distributed random number between the s0, 1. It is the individual best understanding for particle and the better particle of group of first particles found so far in position and velocity. The traditional PSO algorithm has the disadvantages of slow convergence and premature convergence in resolve intricate functions. In order to increase the quality and convergence properties of the solution, Two modes are present in the literature. One is to consider weight of inertia (IW) and the other is the shrinkage coefficient (CF). CF-PSO has been made to be good in solving best problems compared with IW-PSO. Therefore, CFis considered, and the use of

$$\emptyset_{id}(k+1) = x[\emptyset_{ij}(k) + c_1 r_1 (P_{bij}(k) - P_{ij}(k) + c_2 r_2 (P_{gi}(k) - P_{ij}(k)]$$
(8)

$$x = \frac{2}{|2-\varphi-\sqrt{\varphi^2-4\varphi}|}, \varphi = c_1 + c_2 \text{ and } \varphi > 4 \quad (9)$$

PSO-base MPPT technology was implemented successful at MATLAB-2014b situation to analyze the optimal duty ratio to maximize power. The MPPT controller measures V-pv and I-pv over the sensor calculates the output control. Algorithm started with casual initialization of the speed ,particles (duty ratio of Zeta converter) in smallest to extreme duty-bound range. Fitness Function (FF) of the MPPT's is well-defined as

$$FF = maxP_{pv}(D) \quad (10)$$

best duty on ratio. The duty ratio varies between 0 and 1. early duty-off ratio, minimum suit value afterwards the last repetition are specified as resident and universal best locations. In following stage of process, elements in the group trail the rules for updating based on (10) and (8) speed and position. Due to the random nature of the PSO, the element might not be updated close to the earlier position. In this case, a un expected change in D will effect in a great voltage concern on switch Q. Therefore, compelled ratio is arranged based on the previous value obtained and most recent Duty-off ratio taken into account to lessen switching stress. iterative process lasts in the identical way till the hostage spreads the highest set value and selects the best solution after the highest number of iterations. Otherwise, add the iteration counter and re-evaluate the fit value. When any changes in shadow mode are noticed, the particles in the group are reinitialized. The supreme repetition count is set to fifty and then the number of particles in the algorithm is set to 5. During the unification and partial darkening of the photovoltaic array, recommended MPPT controller will successfully tracks the universal supreme power.

Power management control strategy

Two converter control of DC-DC is sitting on the preservation of a continuous DC in "BLDC" under numerous biosphere circumstances. The electricity management algorithm used here in the paper contains two circuits for the production of reference electricity (IREF) needed to preserve the continuing DC-Voltage. use for the organizer of Proportional integration (PI) to produce an iref for the HESS system. In addition, it has been divided into the cells of super condensers on individual control, the current expression is the Converter control of DC-DC is breaking on the preservation of a continuous DC in "BLDC" under numerous biosphere circumstance.. the current phrase is next the expression for reference current is as given below

$$I_{ref} = \left(k_p + {}^{k_i}/_{s}\right) \times V_{error} \quad (11)$$

K_P ,K_I is proportional and overall gain, correspondingly. The worth of K p, KI can be assessed by our Ziegler-Nicholas system.[17]. PI is a weighted sum of the control operation performed using the integral value of the error & feedback controller. In response to the error ratio the constant Kp is called proportional gain is multiplying and adjusted. The contribution from the integral term is proportional to the size of two errors and errors of time. The first error is multiplied by integration. The error is the first time the integral gain, Ki is multiplied, and accumulated offset obtained by integrating previously been corrected. Input to the PI controller is the difference between the reference value and the error value of the voltage. Error value according to the comparison with the reference voltage value, from which the linear PI regulator proportional and integral gains Kp &KI to reduce the steady state error to zero.

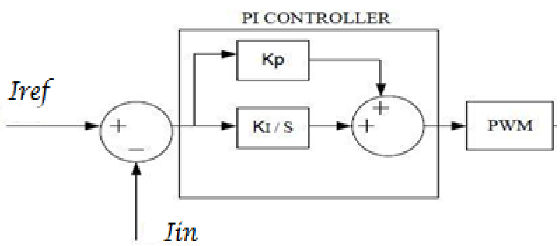


Fig.4 Basic PI control

IV. PROPOSED WORKS

With the PI Controller the errors may not reduce quickly due to fixed gains and this controller does not operate according to the system condition. PI linear controller which does not make the system stable accurately. The drawback overcome by using the fuzzy controller. This is non linear controller which is operating according to the system conditions in which we give the set of rules. These rules help us to reduce the errors by comparing the errors and change in error and we get required output to make the system stable quickly and accurately. Function of fuzzy controller is very precise as to reduce the system from the tedious mathematical modeling & computing & useful. Fuzzy controller performance is recognized for two momentary & steady state improvement. I.e. fuzzy controller comprises four main functional blocks; knowledge, fuzzification, inference and defuzzification mechanism.

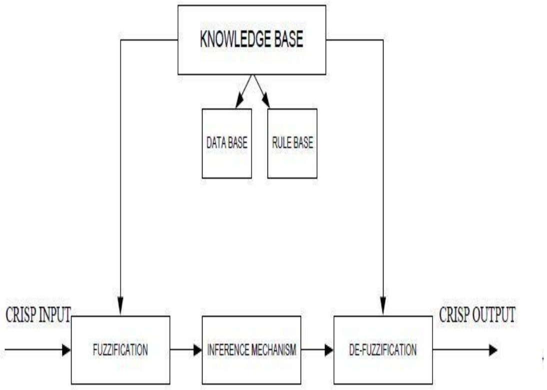


Fig .5 schematic diagram of FLC

The system using the FLC controller Mamdani type inference method will be described. The fuzzifier transforms the input variables and controller performs the logic operation and gives the output according to inputs The .controller having knowledge base and inference consists of membership functions and fuzzy rules to perform operation according to environment.The defuzzifier converts fuzzy output to the required system output.

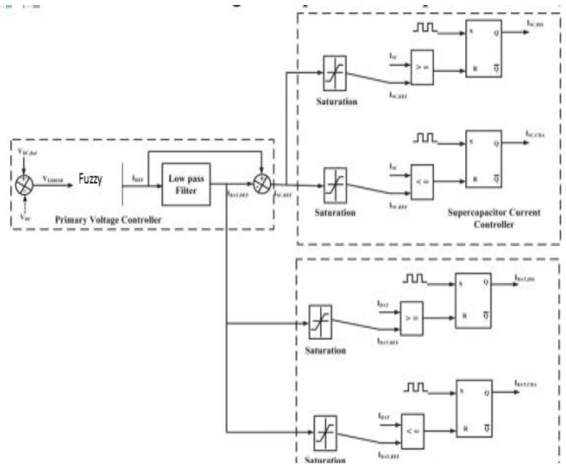
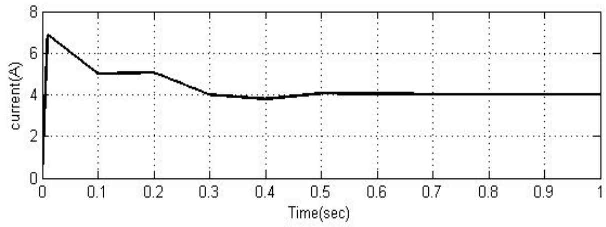


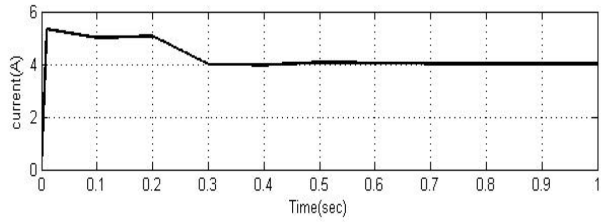
Fig.6. Power management control strategy

Two converter control of DC-DC is sitting on the preservation of a continuous DC in "BLDC" under numerous biosphere circumstances. The electricity management algorithm used here in the paper contains two circuits for the production of reference electricity (IREF) needed to preserve the continuing DC-Voltage. use for the organizer of FUZZY logic controller(FLC) to produce an iref for the HESS system. In addition, it has been divided into the cells of super condensers on individual control. The reference that was obtained from the separation of low-filter segregators provides a battery reference and super condensers. Comparing the error derived from references and actual current, the reset needle is Danny. If the real electricity is higher than the reference power, the battery and the super condenser will be transferred to the discharge regime and will be in the fill mode, and the real one is lower than the value of recommendations. It gives data .5 detailed describing administrative control consultants.

V. V. RESULT AND DISCUSSION



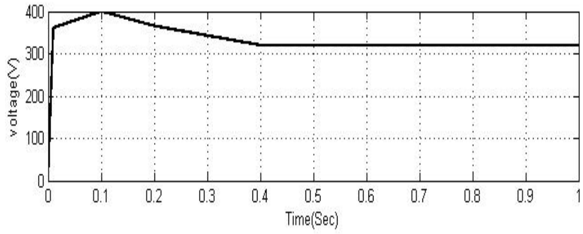
a. Using PI Controller



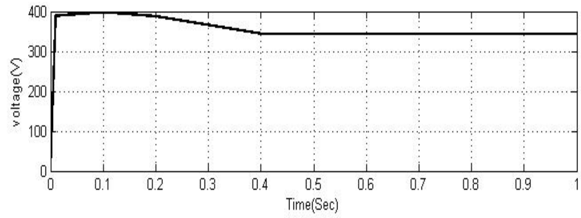
busing FUZZY Controller

Fig.7a.b: Comparison of load current

The load current of the system with pi controller can be stable at 0.5 sec.But here proposed fuzzy controller can stable the system load current quickly at 0.3 sec then pi controller.



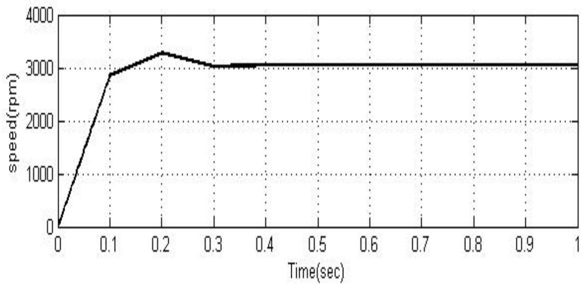
a.Using PI Controller



b.Using FUZZY Controller

Fig8.a,b:Comparision of Load voltage

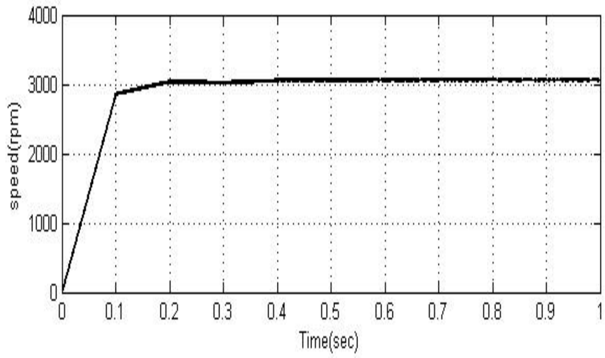
The load voltage magnitude ripples can be reduced with fuzzy logic controller compared to pi controller



a. Using PI Controller

Retrieval Number: B7828129219/2020©BEIESP
DOI: 10.35940/ijitee.B7828.019320

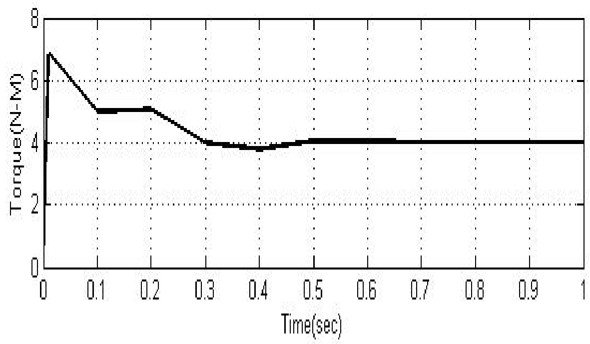
Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication



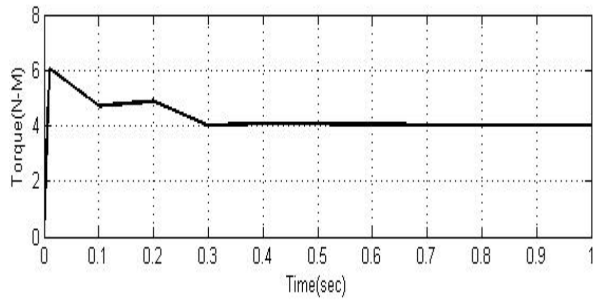
b. Using FUZZY Controller

Fig.9a, b: Comparison of Rotor speed

The rotor speed is stable at 0.3 sec with pi controller. By using fuzzy logic controller rotor speed can be stable at 0.1 sec.



a. Using PI Controller



b. Using FUZZY Controller

Fig.10 a, b: Comparison of Torque

The torque of the system can be stable at 0.5 sec with pi controller. By using fuzzy controller we can stable the system quickly at 0.3 sec

Table II Comparison of PI-FUZZY Control for Various Parameters PV-HESS based ZETA Converter

Table II

Parameters	PI Settling time(sec)	FUZZY Settling time(sec)
Load current	0.5	0.3
Load voltage	0.4	0.4
Speed	0.3	0.1
Torque	0.5	0.3

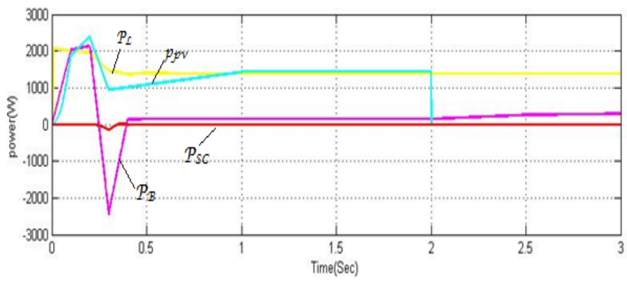


Fig.11 Power managing curve of pv- Hess fed bldc motor drive for a change of irradiance from 1000w/m2to 0w/m2 at 2 seconds.

From above figure first the pv supply the power according to load demand from 0-2 seconds. In this time the hybrid energy storage system will be in charging state. when irradiance falls to 0w/m^{2}then the battery will supply the load demand.

VI. CONCLUSION

The performance of PV fed BLDC drives, using various control techniques, has solved in this thesis. The recommended controller causes the system to make any type of error. These controllers have their own advantages and use different methods to control load parameters according to system condition. Existing controller does not stabilize the system quickly and steadily. But recommended controller in this thesis use control technology such as member ship functions to stabilize the system too fast. It can be concluded that the PV fed BLDC driver using the HESS-assisted Zeta converter has been proven as an effective alternative to conventional energy use.

The Zeta converter is well performed in terms of MPPT and the motor drive runs smoothly. In addition, the power management algorithm for HESS systems maintains a constant voltage of the BLDC motor. Various expected performance, such as PSO-based MPPT in different climatic conditions, zeta-converter operation, dynamic performance of the overall system has been proven in the form of using MATLAB/Simulink board.

REFERENCES

1. Subdhi.B and R. Pradhan,: “A comparative study on maximum power point tracking techniques for photovoltaic power systems,” IEEE Trans. Sustain. Energy, vol. 4, no. 1, pp. 89–98, Jan. 2013.
2. B. Bendib, Belmili.H and Krim.F: “A survey of the most used MPPT methods: conventional and advanced algorithms applied for photovoltaic systems,” Renew Sustain Energy Rev, vol. 45, pp. 637–648, 2015.
3. R. A. Koad, Zobaa.A.F and A. El-Shahat,: “A novel MPPT algorithm based on particle swarm optimization for photovoltaic systems,” IEEE Trans. Sustain. Energy, vol. 8, no. 2, pp. 468–476, Apr. 2017.
4. Shankar.V.K.A, S. Umashankar. Padmanaban..S, M. S. Bhaskar, Ramachandaramurthy.V.K. and V. Fedák, :“Comparative study of photovoltaic based power converter topologies for pumping applications,” IEEE Conference on Energy Conversion (CENCON), Kuala Lumpur, Malaysia, pp. 174-179, 2017.
5. B. Singh and Bist.V,: “Power quality improvements in a zeta converter for brushless dc motor drives,” IET Sci. Meas. Technol., vol. 9, no. 3, pp. 351– 361, May 2015.

6. V. Bist and Singh.B,: “A brushless DC motor drive with power factor correction using isolated zeta converter,” IEEE Transactions on Industrial Informatics, vol. 10, no. 4, pp. 2064-2072, Nov. 2014.
7. Thagvee.M.H, M. M. Radzi, S. M. Moosavain, Hizam.H and M. Hamiruce,: “A current and future study on non isolated DC-DC converters for photovoltaic application,” Renew Sustain Energy Rev, vol. 17, pp. 216-227, Jan. 2013.
8. Kumar .R and B. Singh,: “BLDC motor-driven solar PV array-fed water pumping system employing zeta converter,” IEEE Transactions on Industry Applications, vol. 52, no. 3, pp. 2315-2322, May-June 2016.
9. S. K. Kollimalla, Mishra.M.K, A. Ukil and Gooi.H.B.,: “DC grid voltage regulation using new HESS control strategy,” IEEE Transactions on Sustainable Energy, vol. 8, no. 2, pp. 772 781, April 2017.
10. Kotra.S and M. K. Mishra, :“A supervisory power management system for a hybrid microgrid with HESS,” IEEE Transactions on Industrial Electronics, vol. 64, no. 5, pp. 3640-3649, May 2017.
11. S. K. Dash, Panda.G, P. K. Ray and Pujari.S,: “Realization of active power filter based on indirect current control algorithm using Xilinx system generator for harmonic elimination,” International Journal of Electrical Power & Energy Systems, vol. 74, pp. 420-428, 2016.
12. Kennedy.J and R. Eberhart,: “Particle swarm optimization,” Proc. IEEE Int. Conf. on Neural Networks, pp. 1942–1948, April 1995.
13. K. P. Panda, and Mohapatra.S,: “Anti-predatory PSO technique-based solutions for selected harmonic elimination in cascaded multilevel inverters,” Int. J. Industrial Electronics and Drives, vol. 3, no. 2, pp. 78-88, 2016.
14. Shi.Y and R. C. Eberhart,: “Empirical study of particle swarm optimization,” Proc. Congress on Evolutionary Computation, 1999, pp. 1950–1955.
15. M. Clerc and Kennedy.J,: “The particle swarm—explosion, stability, and Convergence in a multi dimensional complex space,” IEEE Trans. Evol. Comput., vol. 6, no. 1, pp. 58–73, 2002.
16. Eberhart.R.C. and Y. Shi,: “Comparing inertia weights and constriction factors in particle swarm optimization,” in Proc. Congr. Evol. Comput. (CEC), pp. 84–88, 2000.
17. P. M. Meshram and Kanojiya.R.G., “Tuning of PID controller using Ziegler-Nichols method for speed control of DC motor,” in IEEE-International Conference On Advances In Engineering, Science And Management (ICAESM), Nagapattinam, Tamil Nadu, pp. 117-122, 2012.
18. S. Kochanneck, Mauser.I, B. Bohnet, Hubschneider.S, H. Schmeck, M. Braun, and Leibfried.T, “Establishing a hardware-in-the-loop research environment with a hybrid energy storage system,” in IEEE Innovative Smart Grid Technologies-Asia (ISGT-Asia), 2016.

AUTHORS PROFILE

Pudi Roja Ramani, P.G. Student, EEE Department Pragati Engineering College, Surampalem. Her area of interest in research work is Photovoltaic systems, Power Electronic controlled drives.

Sheik Mahaboob Shariff, Associate Professor, EEE Deprtment Pragati Engineering College, Surampalem. His Qualification is M.Tech (Power Electronics & Electric Drives). His areas of interest in research work related to Electric machinery, Photovoltaic systems, Power Electronic controlled drives.

M. N. V. Venkata Brahmam, Assistant Professor, EEE Deprtment Pragati Engineering College, Surampalem. His Qualification is M.Tech (Power Electronics). His areas of interest in research work related to Power systems, Power Electronic controlled drives, Photovoltaic systems.