Journal of Engineering and Applied Sciences 13 (15): 6238-6245, 2018
ISSN: 1816-949X

Study of Photovoltaic Maximum Power Point Tracking Fed DC Motor Improvement Performance

Nashwan S. Sultan, Bashar A. Hamad and Ahmed G. Abdullah
Technical Engineering College, Mosul, Iraq

Abstract: The photovoltaic cells have been operated to produce the energy power supply depended on the environment weather factors (radiation, temperature). The environment state conditions should be identified to regulator the organization of the highest power point onthe photovoltaic cells. This research has been studied, designed and tested for searching the highest point of generated power by solar cells through speed control direct current separately excited motor. A mamdani type of fuzzy logic control has been studied and designed. A Genetic algorithm has been studied and programed to overcome of the computation time which used to obtain the gains of fuzzy logic controller. The hybrid controller (fuzzy logic based on the Genetic algorithm) had been operated to tracking the highest point of the PVcells generated power and improving the performance of the motor speed response. The comparative study between open loop system and closed loop system results with variables environment state and load torque disturbance.

Key words: Photovoltaic cell, direct current motor, fuzzy logic, Genetic algorithm, disturbance, loop

INTRODUCTION

A renewable electrical source is attractive progressively chief. The PV cells produce electrical energy source deprived of external fueland several advantages for example without fuel cost and negative effective to the atmosphere. The tracking of highest generated power point for the PV cells are meek in a solar scheme. The photovoltaic cell is wanted fewer keep, price and not at allnegative active to atmosphere. The PV cells efficiency scheme is fewer related toother generation scheme for example oil and hydraulic stations. PV cells regulator is contingent on the weather state.

Many papers have been presented to resolve the problem of highest power point searching and speed control of dc motor strategies. The definition of the ideal working topic of the PV provided direct current motor driving structure with adapted Genetic algorithm is studied and designed to search the future fuzzy logic NARX-grounded regulator for the documentation of the highest point on the PV cell generated power. The advanced algorithm grounded on identical of the PV cell to the over load dc motor with DC-DC converter type buck-boost in order to joint scheme can work at the finest topic. The input factors to the fuzzy logic NARX classical were PV radiation and running temperature temporarily. The production factor is the chopping part of the converter consistent to the highest output power of the PV cells. The buck-boost converter duty cycle ratios at altered PV factors were gotten after the hybrid fuzzy logic NARX-grounded controller (Anh *et al*., 2012). The improvement created method for overall cross-tied linked units in a PV cell. The positions of the elements continue unmoved though the electrical contacts are changed. The GA by way of improvement device bounces the joining medium for the novel electrical joining which makes the highest output power from the PV collection (Deshkar *et al*., 2015). A different FL controller based good system performance of a three phase PV system network linked inverter. The aided DC to AC inverter and FL controller depended on current and voltage arrangements, a numerical processor controlled signal panel produces the SPWM signals for the inverter action in both separate and grid-connected ways. The system proves steady ac production voltage acceptably with grid and load turbulences (Hannana *et al*., 2015). The comparative analysis study between conventional proportional integral controller and fuzzy logic controller of PV cell that is excerpt highest power after the PV to source a DC motor. The highest power point searching method is needed meant at all PV structure. The Perturbation and Observation method has been used to search highest power from PV cell. The produced step up voltage available from the PV cell, the SEPIC converter is studied and tested. The chief advantage of the converter is producing non-reversed output. The converter performance by way of the border between PV unit and DC motor (Shanthi *et al*., 2017).

Corresponding Author: Nashwan S. Sultan, Technical Engineering College, Mosul, Iraq

The fuzzy logic constructed highest power point searching through an unintended controller below changing weather factors and steady state condition. A simulation effort treatment with highest power controller and a boost DC-DC converter through an indirect controller. The comparative between proportional integral and fuzzy logic controllers are to assess the act in relations of tracking to fast irradiance alteration. The simulation output results presented the FL controller had best performance associated by the PI controller. The FL controller has been decreased oscillation and it delivers fast reaction below fast PV irradiance variations. In addition, it did not need slightly change of the strictures, different straight PI controller (Kasbi *et al*., 2017). The realization by regulatory switching basics in DC-DC step up boost convertor transferring the PV cell energy to its load. A novel technique in highest point of the searching PV cell power centered on FL controller 2 and associates its actwith the FL controller 1. The PV organism as collected of the PV cell, DC-DC step up boost convertor, FL controller part and the load was explained and simulated in the program (MATLAB). In addition, the experiment exam that has been completed for authentication (Soltani and Kouhanjani, 2017). An applicable improvements completed in the arrangement of the stated stage. A highest power point searching method deepened on FL controller that included in the stage of a contrast to the perturbation and observation and incremental conductance methods. A three control methods were related in the reproductions of computer and experimental application in the stage stated previous. Results prove the improvement of the future alterations (Novais *et al*., 2017). The education and design pointed the highest point of the PV cell generated power with DC motor response speed performance improvement. Whereas perturbation and observation algorithm, PID and PID dependedon bacterial foraging optimization technique controllers were worked to exploration the highest point the PV cells generated power and motor improvement speed response below several environment elements and motor load torque trouble (Narayan and Pratibha, 2017). The amount of the generated power in the PV cells was contingent proce eding to produced voltage and the highest power realized straight by the weather limits factors. The PV cell representative signal offers the highest created power and photo voltaic cell proposal the highest point of the PV cell generated power with top efficiency. The fuzzy logic controller based on genetic algorithm has been studied, designed and advanced to becomethe highest point of the PV cell generated power. It is able to change sunshine energy to an electrical energy. The atmosphere elements straight consequence on the produced the electrical energy with highest power point was variation through these elements.

MATERIALS AND METHODS

PV cell model: The structuremodel of PV cell that constructed as semiconductor (p-n) junction material piecewas displayed in Fig. 1. A terminals of the photovoltaic cell are linked with binary terminal means, that matched similar a diode and create a photo-voltage electrical power contingent through the sun charging (Sultan, 2018) (Table 1):

$$I = I_{SC} - I_O \left\{ \exp\left[\frac{q(V+R_S I)}{nkT_k} \right] - 1 \right\} - \frac{V+R_S I}{R_{Sh}} \quad (1)$$

Where:

V, I = The output produced voltage and current of PV cell
R_{sh}, R_s = The PV cell parallel and series resistances
q = The PV cell electronic charge
I_o, I_{sc} = The opposite fullness current and the light produced
n = The PV cell dimension less element
k = The PV cell Boltzman constant
T_k = PV cell temperature that expressed in kelvin unit

Buck converter: The buck converter that worked as DC-DC (step down) converter. It produced the production voltage was smaller compare with its converter input voltage while K was represented the converter duty cycle firing angle ratio of the switching and its output voltage is expressed in Eq. 2:

$$V_o = V_s/(1-K) \quad (2)$$

Whereas:

V_s = Input voltage
V_o = Output voltage of converter
K = Duty cycle ratio which equal to $(ton/[t_{on}+t_{off}])$ and switching frequency is equal to 4 KHz

Direct current motor: The DC motor can be used in extensively applications. The modification group of DC linking motor (shunt, series, compound and separately excite). The motor field windings has been produced both active and steady-state appearances with greatdifference in its volt-ampere and speed-torque relations. The DC motor can be simply controlled and applied in several requests for example moving door direction and other. (Sultan, 2018; Narayan and Pratibha, 2017).

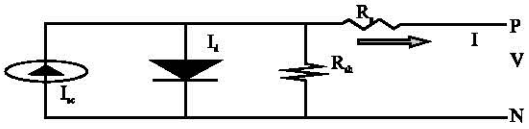

Fig. 1: The PV cell system

Table 1: PV cell parameters

Variables	Values
PV Wight (kg)	19.5
Dimension of PV cell (cm)	168*1.18*5
Highest photovoltaiccell produced power (W)	367
Biggest produced current byPV cell (A)	6.62
Highest PV voltage (V)	61.4
Highest PV cellproduced current (A)	6.13
PV cell no load produced voltage (V)	66.1

Table 2: The elements value of DC motor

Va = Vbuck, Vf = 190 (V)	Lf = 19.68 (H)	La = 0.024 (H)
Rf = 256 (Ω)	Lm = 1.85 (H)	B = 0.005 (N.m. s/rad)
Ra = 3.5 (Ω)	J = 0.066 (kg.m2)	Kb = 1.4 (V/A-R/S)

The current study which used of the separated excitation DC motor kind is certaincontingent on its finest mechanical and electrical acts associated with the additional DC motor kinds. The motor has been driven and operated by useful outside source voltage to its field winding. The static field current and adjustable armature current which can be used armature, control way. The separately excited DC motor parameter factors are amplification in Table 2.

Fuzzy Logic Controller (FLC): FLC has been studied and designed with a two-inputs and one-output signals. The error signal E (t) and the change of the error signal ΔE(t) have been expressed as input signal for the FLC. The linguistic variables are clear as (NegB, Neg, NegS, Zer, PoS, Po, PoB) where NegB-negative big, Neg-negative, NegS-negative small, Zer-zero, PoS-positive small, Po-positive, PoB-means positive big. The fuzzy logic controller with triangular member ship function has been considered (Ahmad and Sultan, 2014; Kushwah and patra, 2014). The fuzzy logic base rules are briefed in Table 3. The gauge rang for together signals are measured between (-40 and 40) the error signal and (-30 and 30) for the change of error input signal. The output signal range of the FLC that set between (0-1) and has been compared with the triangle wave signal with frequency 4 kHz and fed to DC-DC buck converter to control the voltage value which applied on the DC motor armature terminals.

Genetic Algorithm (GA): Genetic algorithm has been extensively application in control method because of its ability to effort by way of an optimization reasons in its position of the conservative control kind. GA method is careful as an hybrid technique for penetrating the explanation of hard problems anywhere it can be ability in joining with other intelligent means. It contains of several stages which explained (Deshkar *et al*., 2015; Pandey and Tiwari, 2017; Kushwah and patra, 2014; Kim *et al*., 2007).

Table 3: Genetic algorithm parameters

Parameters	Values
Number of string (population)	50
Number of generations	30
Probability of crossover (P_c)	1.0
Probability of mutation (P_m)	0.01

Initial population: A chance initial population of 50 dissimilar, decimally resolute has been used separately single distinct with two genes, animated the crop two FL controller gains. The initial population methods a matrix of (40*2) sizes. A software design way for climbing the initial good of the chance persons after the period (0-1) to the additional period has been strategic.

Fitness function: The normal of deduction the Integral Absolute Error (IAE) by way of an performance index has been acted to chief the examination of the genetic algorithm and apparent to reduce this error done the choice and recombination of the linked individuals concluded every the generations.

Selection: A selection way used in the genetic algorithm that called the modified roulette selection method which varied of the composed selection way of the biased chance selection and the snootiness selection way. The resolution of by means of a mixture selection technique is method to decrease the problems of the roulette wheel and by means of the elitism principles with a exact high selectiveness degree which is the slow passing to sign and travel new examination areas. So, the selection method which was produced, keeps the finest 20% individuals and fees them progressing to the next generation deprived of slightly variable and practical the roulette wheel variety on the residual 80% of the population.

Crossover: As of the certain individuals have been remained decimally encoded that offered to recombine the individuals and way those of the next determined group. This method can be used in knowledge to abridge the skill of selecting the bounds of the initial population standards for the alike devices clearly. Then the result of the similar mechanisms is evocatively alike that we selected to hurdle each two a similar mechanisms after their decent examination space. Several crossover dues were stressed and the main degree used was 100% of the recombined individuals (Table 3).

Mutation: The mathematics alteration used in this algorithm. Too mean while of the decimal programming of the apiece individuals.

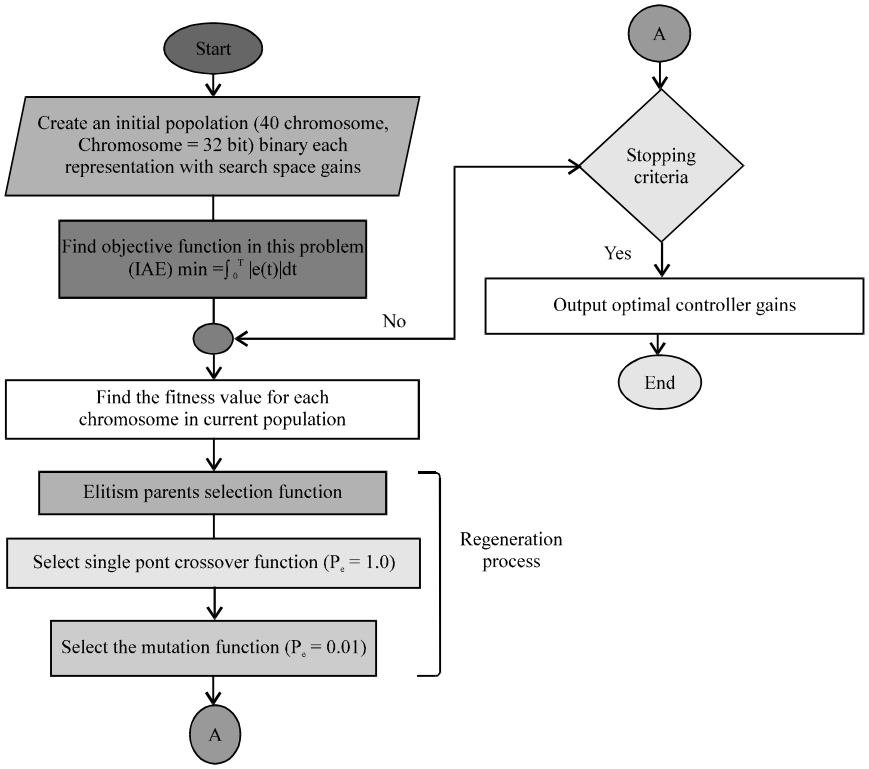

Fig. 2: Hybrid algorithm flowchart

Stopping criteria: It is layer a multi-condition stop principle of the Genetic algorithm and presented parameters such as (steady state error, peak over shoot, settling time).

Hybrid fuzzy logic controller based on Genetic algorithm: To produce the optimal performance results of the considered system the FL controller gains have been calculated by using the Genetic algorithm. It is programed in MATLAB program to search of its ideal FL gains value). The Genetic algorithm is linked with the planned simulation structure. The finest performance was produced with a smallest objective function. The integral absolute error way that used toproduce best objective function. These given three gains value that like to calculated FLC gains. The original generation place should be selected and limited. The act supplies (settling time, rising time, highest over shoot, stable state error) were significant to regulate and relate a want orientation signal and its working signal. The simulation planned algorithm has been produced to the general error signal as the objective purpose to calculate a FLC elements in tried space. M-file Genetic algorithm programed with FLC at the selected settings are the peak over shoot (lower 5%), the peak stuady state error (lower 1%), the settling time (lower 0.28 sec) and rising time (lower 0.24 sec) The

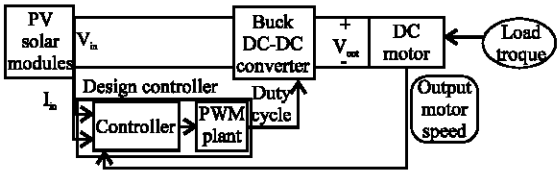

Fig. 3: The design block daigram system

flowchart of FLC adabtive GA is assumed in Fig. 2 and the whole block daigram of the system assumed in Fig. 3.

RESULTS AND DISCUSSION

For Fig. 4-10 which created the relative that produce the PV cell power which proportionately with the radiation and contrari wise by the temperature of the sun. Figure 5 that expressed of the generated power by the PV cell under constant environment factors 1000 w/m^2 radiation and temperature 43 °C and without highest power point searching controller. Figure 6 that offered the speed response of DC motor under the variation load torque (6-9-3) Nm at time (1-1.5) second and without controller design. Figure 7 which produce the highest power of PV cells with variable environment factors and references speed. For Fig. 8 which given the speed

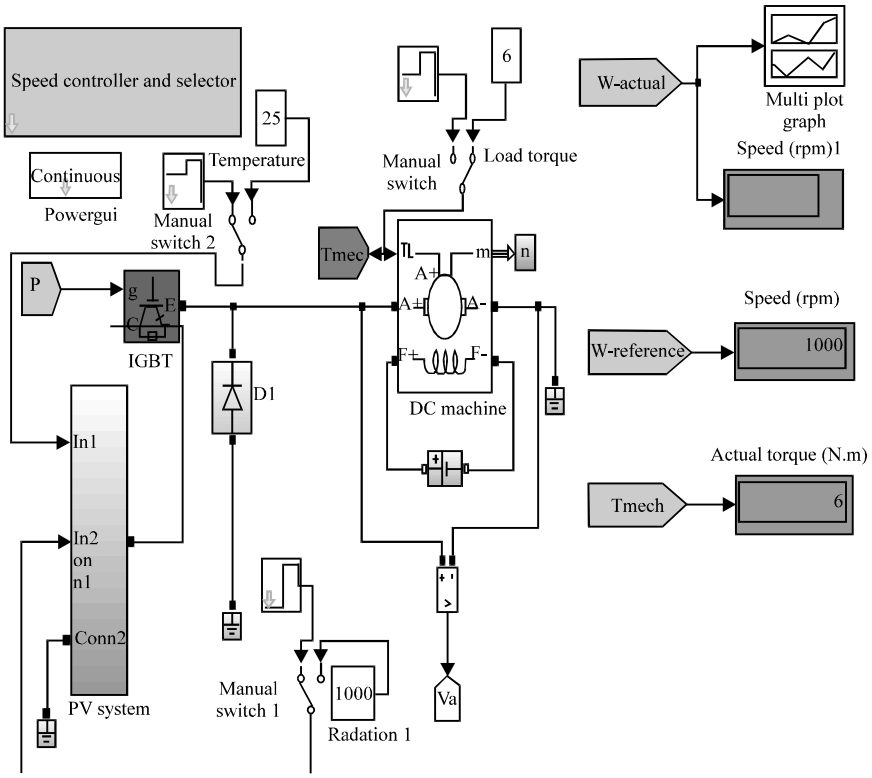

Fig. 4: Simulation MATLAB system

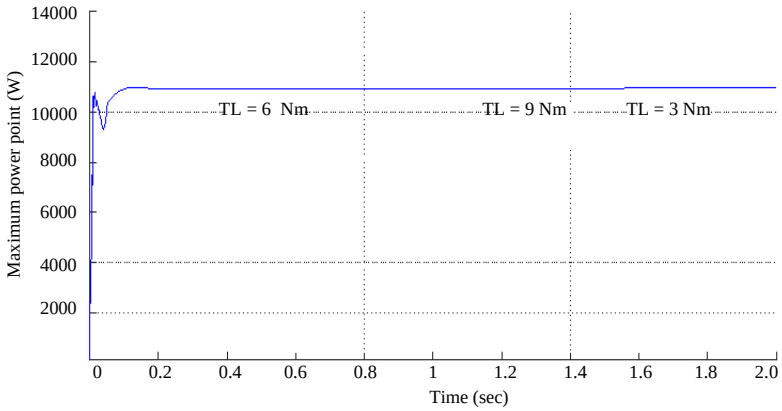

Fig. 5: Open loop PV system power response

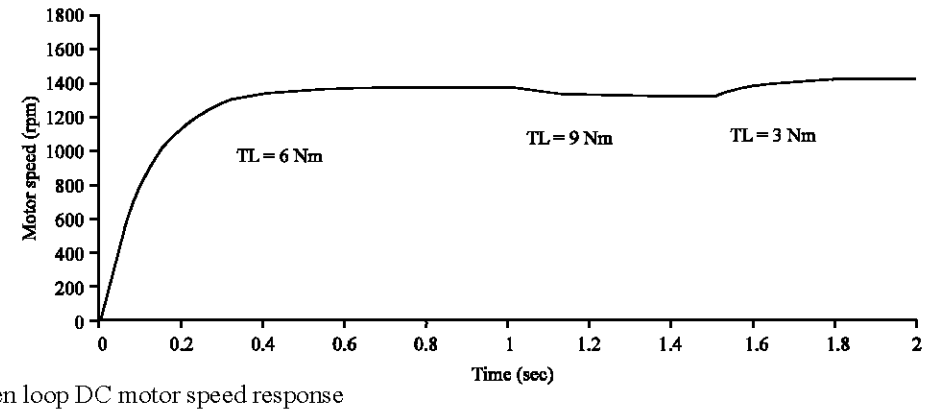

Fig. 6: Open loop DC motor speed response

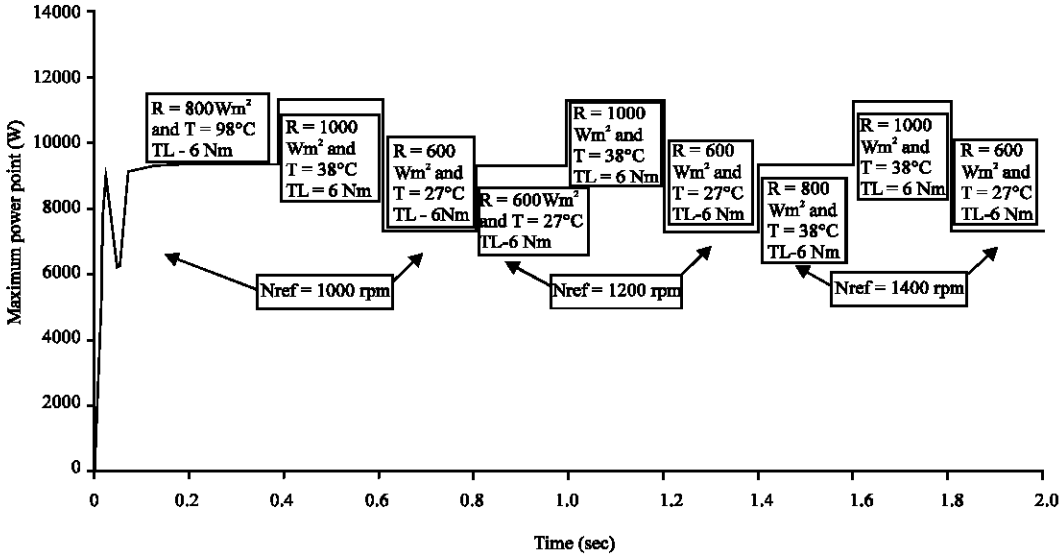

Fig. 7: Close loop PV system power response with hybrid FL/GA controller under variation in reference speed and environment conditions

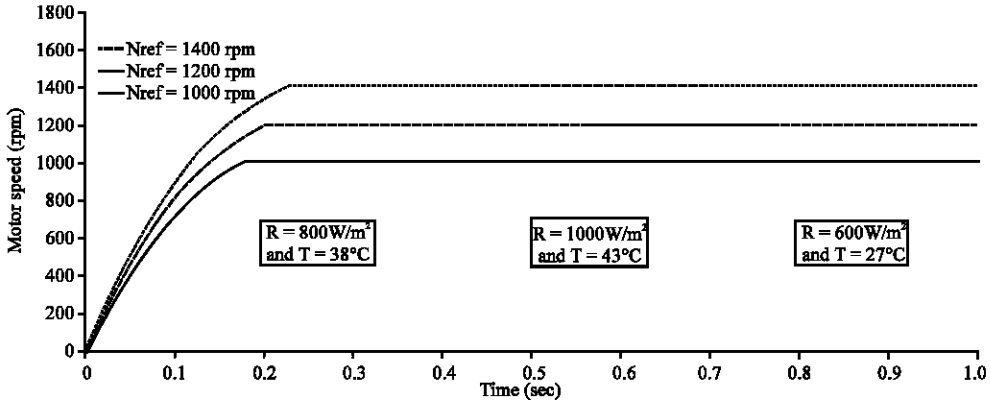

Fig. 8: Close loop DC motor speed response with hybrid FL/GA controller under variation environment conditions

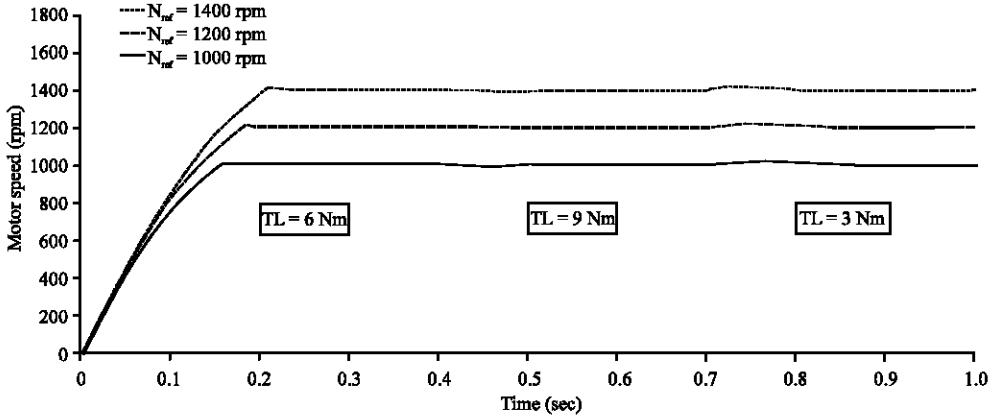

Fig. 9: Close loop DC motor speed response with hybrid FL/GA controller under variation load torque

responses with variable environment factors and Fig. 9 that express of the DC motor speed responses when load torque variable and fixed environment factors. Fig. 10 is given the sequence speed responses with constant load

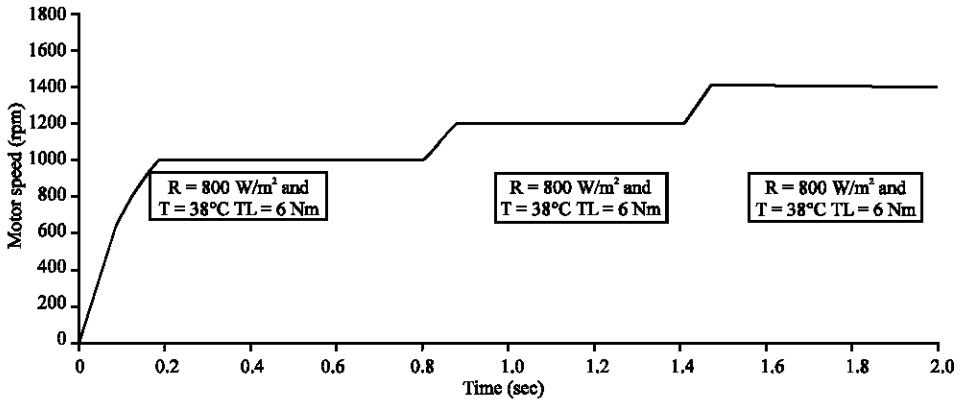

Fig. 10: Closed loop response sequence of DC motor speed with hybrid F

Table 4: PV cell results comparison

R (w/m^2)	T (°C)	V (volt) cells	P_{max} without load (W)	P without controller (W)	P (W) with FL based GA controller
1000	43	241.4	10948	10936	10930
800	38	221	8737	8723	8717
600	27	209	6539	6526	6520

Table 5: DC motor results comparison

Design system	Steady state error at TL = 6 Nm	Peak over shoot (p.o.s) (%)	Setlling time (t_{ss}) (sec)	Rising time (t_r) (sec)	Delay time (td) (sec)
Open loop response when duty cycle of buck converter = 70%	5.66	0	0.589	0.2885	0.019
Close loop response when hybrid FL/GA controller	0.143	0.57	0.233	0.170	0.0165

torque and environment factors. The comparative results between open loop system and closed loop system when FLC based on genetic algorithm that produced in Table 4 and 5.

CONCLUSION

The PV cells studied, analyzed and designed with the DC-DC step down buck converter. It has been loaded by separately excited DC motor. The system is express by matlab program whereas the simulated system results of the designed scheme had been studied. The output generated powerof the PV cells had been calculated below the several weather settings. The DC motor has been studied and speed control to improve the optimal performance. Fuzzy logic based Genetic algorithm has been designed to improve and search of tracking the highest point of the PV cells generated power. This technique has been worked to advance the motor output speed response performance. The speed response of the DC motor and highest power of the PV cells through the hybrid techniquehas been compared the results which produced by the tested system. These results below the many weather factors and with external disturbance of the load torque. The hybrid FL based on GA controller that offered the optimal performance results of the PV cells and DC motor.

REFERENCES

Ahmad, A.H. and N.S. Sultan, 2014. Design and implementation of controlled Zeta converter power supply. Am. J. Electr. Electron. Eng., 2: 121-128.

Anh, H.P.H., N.H. Phuc, T.T. Huan, 2012. Adaptive fuzzy NARX controller for MPPT PV supplied DC pump motor. J. Eng. Technol. Educ., 1: 313-320.

Deshkar, S.N., S.B. Dhale, J.S. Mukherjee, T.S. Babu and N. Rajasekar, 2015. Solar PV array reconfiguration under partial shading conditions for maximum power extraction using genetic algorithm. Renewable Sustainable Energy Rev., 43: 102-110.

Hannan, M.A., Z.A. Ghani, A. Mohamed and M.U. Nasir, 2015. Real-time testing of a fuzzy-logic-controller-based grid-connected photovoltaic inverter system. IEEE. Trans. Ind. Appl., 51: 4775-4784.

Kasbi, S., E. Rijanto, A. Nugroho and R.A. Ghani, 2017. Comparison of fuzzy logic and PI MPPT algorithm with indirect controller for PV systems. Intl. J. Innovative Stud. Sci. Eng. Technol., 3: 25-31.

Kim, D.H., A. Abraham and J.H. Cho, 2007. A hybrid genetic algorithm and bacterial foraging approach for global optimization. Inform. Sci., 177: 3918-3937.

Kushwah, M. and A. Patra, 2014. Tuning PID controller for speed control of DC motor using soft computing techniques: A review. Adv. Electron. Electr. Eng., 4: 141-148.

Novais, H.H.B.D., E.G. Carati, C.M.D.O. Stein, J.P.D. Costa and R. Cardoso, 2017. Improvement of an emulator-based platform for design of photovoltaic converters and controllers. Proceedings of the 2017 IEEE 8th International Symposium on Power Electronics for Distributed Generation Systems (PEDG'17), April 17-20, 2017, IEEE, Florianopolis, Brazil, ISBN:978-1-5090-5340-7, pp: 1-8.

Pandey, N.D. and P. Tiwari, 2017. Comparison between speed control DC motor using genetic algorithm and PSO-PID algorithm. Intl. J. Electr. Eng. Technol., 8: 17-25.

Shanthi, T., C. Selvakumar and S.U. Prabha, 2017. Design of fuzzy logic controller for speed control of DC motor fed from solar PV system. Intl. J. Electr. Electron. Eng., 4: 5-9.

Soltani, S. and M.J. Kouhanjani, 2017. Fuzzy logic type-2 controller design for MPPT in photovoltaic system. Proceedings of the 2017 Conference on Electrical Power Distribution Networks (EPDC'17), April 19-20, 2017, IEEE, Semnan, Iran, ISBN:978-1-5386-3011-2, pp: 149-155.

Sultan, N.S., 2018. Design and comparative study of photovoltaic maximum power point tracking converter with DC motor speed control. Proceedings of the 1st and 3rd Joint International Scientific Conference on Engineering Sciences (ISCES'18), January 10-11, 2018, IEEE, Diyala, Iraq, ISBN:978-1-5386-1499-0, pp: 74-79.