ISSN:0971-1260
Vol-22-Issue-4-October-December-2019

# Modelling Of Spv System To Charge A Battery By Operating At Maximum Point Usingartificial Neural Networks

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***Abstract:***

In recent years,solar energy is an unavoidable resource, but due to intermittent nature, it gives a challengingtask to establish an energy interconnect. So,Solar Photovoltaic (SPV) system in collaboration with batteries can have efficient and constant power output. This paper presents the modelling of SPV system to charge battery by operating at maximum point using Artificial neural networks. A PV array of 200W is designed and is simulated using varying insolation and constant temperature of 25 From the simulation of Fuzzy logic and Artificial neural networking based MPPT techniques, it is evident that the results obtained by ANN MPPT technique are better than fuzzy logic MPPT method.ANN based system reduces operational time and increases the efficiency of SPV module, and alsogives appropriate current and voltages for efficient charging of battery, thus increasing the battery life span and reducing the ripples in output power.

***Keywords:*** Solar Photovoltaic (SPV) system, Battery charging circuit, Artificial Neural Network (ANN), Discrete-PID, MPPT.

## 1.INTRODUCTION

Electricity is one of the most important factors for the commercial growth of any nation. By capturing light and heat from sun, solar energy is obtained. Due to the energy crisis, every country in the world are moving towards the green technologies. This is because pollution causing greenhouse gases will not be emitted by using green technology. Solar energy is most preferable among non-renewable energy sources.

India is the third largest generator and third largest consumer of electricity but still we are facing the electricity crisis and also the per capita electricity consumption, which is mainly considered to determine the growth of the nations, is very less when compared with the rest of the countries and also average per capita electricity consumption of world. In India the possible generation through renewable energy sources was 114.31GW.The installed capacity was only 69.02GW, where the generation through solar energy alone is 21.6GW. For the year 2018-19 India's electricity demand was 1274.6BU but the generation was 1267.5BU, this shows India is having a deficit of 0.6% in electricity sector.

So, to meet electricity demand, the generation capacity has to be increased. If we go for solar energy, the effect of pollution causing gases is almost nil and can get clean and efficient power. Standalone SPV system gives energy at normal conditions only but solar arraysin coordination with batteries acts as power sources during dark times and also in transient operating conditions(*Pode,2015*). This can also be used in electrical vehicles [6]. Working of solar panel mainly depends upon the changes in solar irradiation and variation in temperature. With the varying irradiation and temperature, we will get different P-V and I-V curves. These curves are not linear in nature (*chang et al., 2015*), this will change the values of current and voltage thus changing the maximum power obtained by SPV system. At MPPT, maximum efficiency is obtained.

Basic solar panel have an efficiency of 7-19% which is very less(*Hq.et.al., 2013*). For increasing the efficiency, there are many MPPT techniques namely, Perturb & observe (P&O) method, Incremental Conductance (IC) method, Fuzzy logic (FL) based method [2], Artificial neural network (ANN) method. The way of choosing algorithm for obtaining maximum power depends on the time taken by the system for the process of that algorithm, tracking of MPP, cost and difficulty of implementation.For a PV system to provide stable electrical power supply, obtaining peak power point and system power regulation have to be maintained at any environmental condition.



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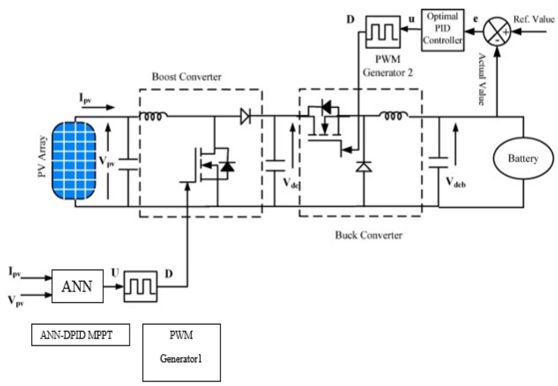
ISSN:0971-1260
Vol-22-Issue-4-October-December-2019



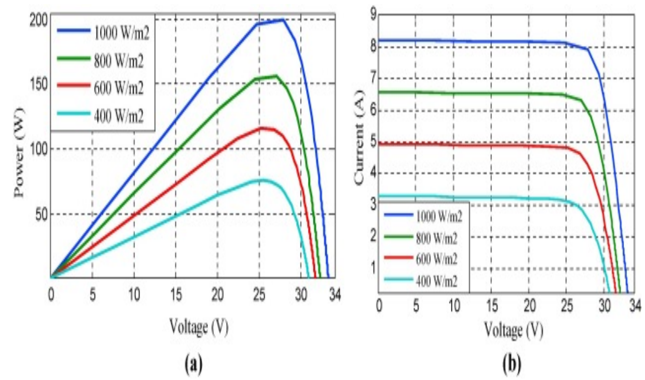




**Fig1**: Battery charging circuit using ANN based SPV system

**Fig2**:(a) P-V curve (b) I-V curves on varying solar irradiance



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ISSN:0971-1260
Vol-22-Issue-4-October-December-2019

Some of the challenges with using conventional MPPT techniques have fluctuation around the optima, and the inability to detect the real maximum power point in a fast manner. Some of the techniques require complicated computations while others are not accurate. Conventional PID controller requires frequent calibration and variation in values will gives desired performance [8],[9]. Output voltage and currents of SPV system are used for selection of MPPT algorithm for generation of PWM [11],[12].In this paper ANN-DPID MPPT method is implemented and with the help of simulation, it is implemented. The solar panel used is of 200W and the variation of irradiance is taken as 400-1000 W/m² and maintained a fixed temperature of 25C.

The remaining piece of paper includes Section 2 explains aboutdescription of solar photovoltaic system, Section 3 deals with different types of MPPT techniques mainly focuses on ANN-DPID MPPT technique, Section 4 consists of results obtained through simulation work, Section 5 have conclusions from the piece of work done and finally section 6 deals with references.

## 2.SOLAR PHOTOVOLTAIC SYATEM DESCRIPTION

PV cells main objective is conversion of solar radiation directly into electricity.Solar photovoltaic system along with batteries is an off-grid electricity system, where useful for the people away from the distribution networks. For the future purpose requirements SPV is designed along with the batteries, batteries act as potent and pocket friendly for the user. Batteries stores energy and deliver as Direct Current, which can be used for lightning as well as for DC applications. Fig2(a) shows the P-V curve and 2(b)has I-V curves of SPV system considering variation due to change in solar irradiation from 400-1000 W/m².

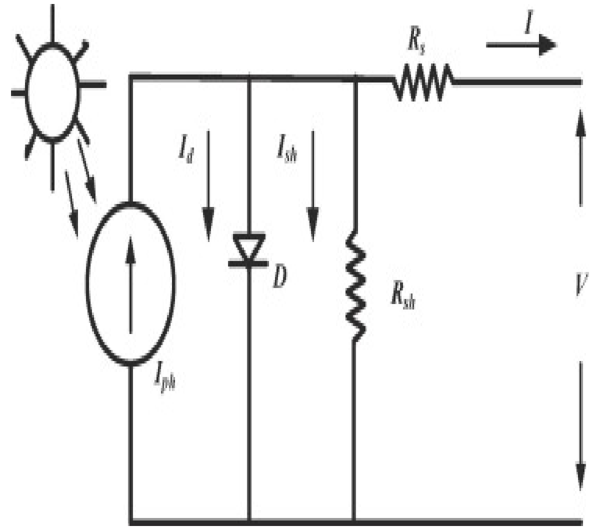


**Fig3**: Equivalent model for solar cell

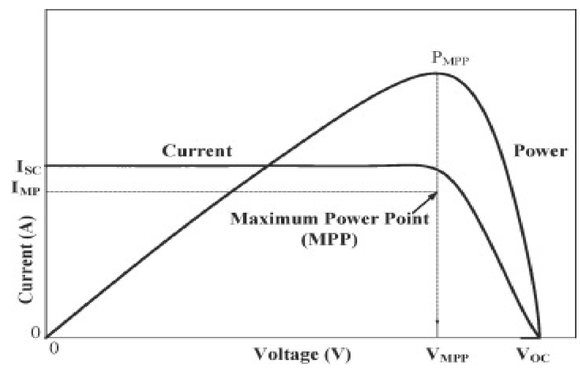


**Fig4**: P-V and I-V curves for MPP



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Vol-22-Issue-4-October-December-2019



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Vol-22-Issue-4-October-December-2019

### *2.1. Equation of a solar cell*



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ISSN:0971-1260
Vol-22-Issue-4-October-December-2019

In this piece of paper, the variations in the solar insolation from 400-1000W/m² and considering constant temperature of 25C.

The equivalent model for photovoltaic cell has so many ways based on the requirement. Among all the possible methods, in Fig3 solar cell equivalent model based on single diode is considered. For this simplified circuit, I-V characteristics are obtained from the equation (1).

I = I(1)

Where,

I- Current source
$R_S$- Series resistance
$R_{SH}$- Shunt resistance
$I_O$ - Reverse saturation current
q- Charge of electron
V-Diode voltage
T- Temperature

The equation (1) givescurrent vs voltage curve. From Fig4, we can get the Power-Voltage and Current-Voltage characteristics by placing them in a single graph. Point where both the curves meet is known as maximum power point (MPP). At MPP, SPV system gives maximum efficiency. Without MPPT technique theefficiency is very less for the SPV system. In MPPT measurement either current or voltage are maintained constant and the remaining parameters are varied to get the desired output. These varied values are given as gate signals to the boost converter in battery charging.

## 3. DIFFERENT MPPT TECHNIQUES

Various MPPT techniques for determining MPP are there.The selection of algorithm should be such that the time taken by conversion should be less. In this paper we will mainly discuss about FL-DPID MPPT method and ANN-DPID MPPT method. P&O method can't determine the MPP correctly ends up with calculating wrong MPP. IC method considers only change in current, cost is high and also efficiency is low. Maximum efficiency is obtained when SPV system reaches MPP point as shown in Fig4.

### *3.1. FL-DPID MPPT technique:*

Fuzzy logic based SPV system overcomes the drawbacks due to P&O method and IC method. When compared with those methods, Fuzzy logic has high efficiency, can reduce the ripples to some extent and also reduces Settling Time (ST). But the fuzzy logic operation will have fuzzification and defuzzification processes. This conversion will take some time thus increasing the time complexity. For stability purpose PID signal is not continuous, so we are using Discrete-PID (D-PID). FL based SPV can't handle the non-linearities in the output voltage, current and power. For reducing the ripples content, for improved efficiency and to decrease the settling time ANN-DPID MPPT technique is proposed.

### *3.2. ANN-DPID MPPT technique:*

Neural networking approach isdeveloped and performed for battery charging unit under variable solar insolation and at constant temperature. The computing time and difficulty in obtaining output is easy through ANNSPV system. The output voltage of ANN-DPID MPPT driven boostconverter. The output witha smaller number of ripples is given to the buck converter controlled by optimal proportional integral derivative controller. This buck converter delivers theconstant output power to the load, that is battery.

Main purpose of employing the buck converter is to give constant power to battery for the purpose of charging. If there are any fluctuations in output current and voltages given to the battery, it may get over discharging or deep discharging, thus reducing the battery life span. Buck converter helps in reducing the ripples in current and voltages, providing battery protection by improving the battery life time. Main purpose of capacitor at load side is to reduce the ripple content reaching the battery which is acting as load. Output of PWM generator acts as duty cycle to the DC-DC converters. For the stability purpose, Discrete PID controller is used along with ANN.

Optimal PID driven buck converter is employed mainly for the reduction of errors, since PID controllers' main purpose is reduction of the errors in charging the battery without getting overheated. If battery gets overheated the efficiency of the battery reduces and lifetime of the battery will drastically fall down. So, fluctuations in the output has to be reduced.

The ANN-DPID MPPT method increases the efficiency of the SPV system to 97.1% which is the highest possible efficiency when compared with the all possible MPPT technique. With FL-DPID MPPT method, efficiency obtained is only 93.21% which is less compared with ANN method. The settling time using Fuzzy logic is 45ms whereas with Artificial neural networking method settling time is 35ms. This shows that the operational time has been



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ISSN:0971-1260
Vol-22-Issue-4-October-December-2019

reduced in ANN method compared with FL MPPT method.



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Vol-22-Issue-4-October-December-2019



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Vol-22-Issue-4-October-December-2019

The Fig5 shows the flowchart of ANN MPPT method.First, we will obtain the basic parameters of SPV array such as temperature, PV array Voltage $V_{pv}$and PV array current $I_{pv.}$ These are also called as short circuit voltage and open circuit current respectively. These are very important for obtaining maximum power point of system. In the second step, can the values of varying temperature T and the solar irradiation. After that ANN will calculate the optimum voltage$V_{opt}$ and SPV array calculates operational voltage $V_{oper.}$ If optimum voltage from ANN and operational voltage from SPV are equal then MPPT is obtained. If not then the variation in these values are considered as error and are given to converter as Duty cycle (D).

Based on this Duty cycle converters are controlled. If D is not calculated properly then converter switches will get the signal for the operation and may get the values for process of next step. If this is happened, then there may be chance of getting improper maximum power point values. So, the duty cycle should be calculated based on the optimum and operational voltages of ANN and SPV systems respectively. Thus, ANN based DPID MPPT method is designed using SPV module voltage and current.

The control strategy of ANN based SPV system for tracking MPP is given as UPID:

(2)

Where, KKare the proportional and integral controller constants taken as 0.7 and 0.3 respectively. Accumulated value of output is taken as .This acts as the reference value for the calculation of duty cycle to the proper operation of converters.

Thus, proposed ANN MPPT method technique is one of the best techniques to get the maximum power point. This technique is best when compared to Perturb and observe, IC, FL MPPT methods in the reduction of ripples, capacity in handling non-linearities, number of explicit input and most importantly efficiency of SPV system.

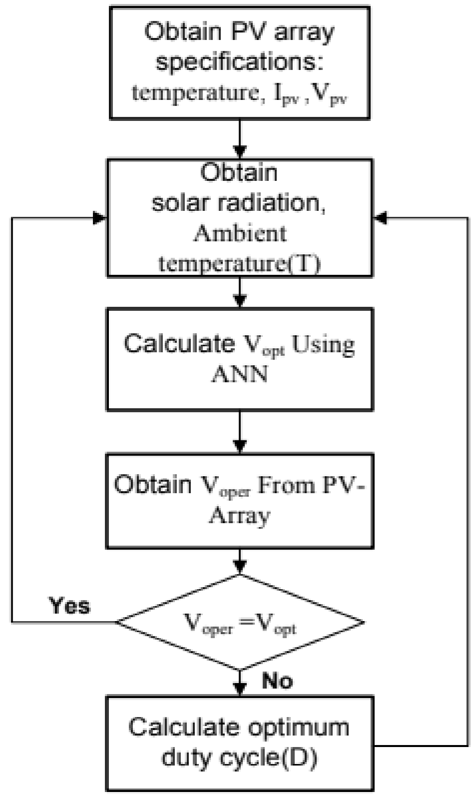


**Fig5**: Flowchart of ANN MPPT method

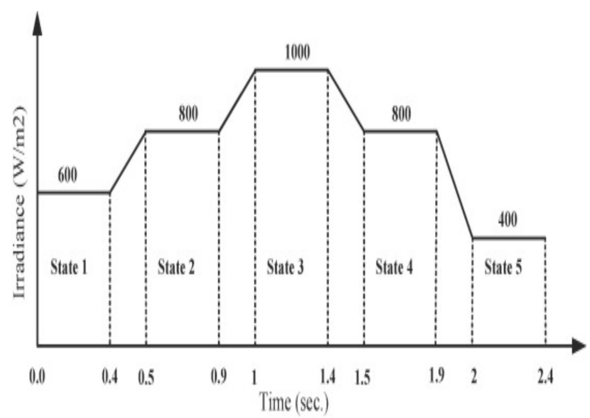


**Fig6**: Variation of Solar irradiance with Time



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Vol-22-Issue-4-October-December-2019



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Vol-22-Issue-4-October-December-2019

## 4. SIMULATION RESULTS:

The entire work is represented in a simple manner in block diagram shown in Fig1. The same model is represented in MATLAB/Simulink software. This is having the designed solar photovoltaic module having a maximum power rating of 200W.Here buck and boost converters are acting as charge controllers. These are working with a frequency of 150KHz. The battery to be charged, which is acting as load is taken as 18V. For the operation of SPV system at maximum power, two different techniques are modeled namely FL-DPID MPPT and ANN-DPID MPPT techniques, for the transient analysis of system and to get the response of SPV module with output current, voltage to get maximum power under changing solar insolation.The variation in the solar irradiance is shown in Fig7, it is having different values of irradiance at different intervals of time. The variation in solar irradiance is in the range of 400-1000 W/m²[13].This is having 5 states each at a constant temperature of 25□C. State 3 is having maximum irradiance of 1000 W/m².

**Table1:** Values of parameters used in simulation

| | Parameter | Values |
|---|---|---|
| SPV | $V_{oc}$<br>$I_{sc}$<br>Cells | 10.908 V<br>8.21 A<br>18 |
| Frequency | $f_s$ | 150KHz |
| Boost | L<br>C | 0.1075mH<br>10.41μF |
| Buck | L<br>C | 0.1613mH<br>1.744μF |

The values corresponding to the buck and boost converters are given in Table1. Both the converters are working at same frequency of 150KHz. Each cell is having 18 modules. Inductance and capacitance of the buck and boost converter are calculated based on the concern formulas of them. Kp and Ki values of proportional and integral controller are taken as 0.7 and 0.3 respectively. Fig7represents the obtained values of output voltage,current andpower of the boost converter used in ANN-DPID MPPT method. Voltage obtained by the solar array is given to boost converter through filter capacitor, this voltage is more than the voltage that is obtained from PV array, that is PV voltage.

**Table2:**Output parameters of Boost and Buck converters, SPV system

| | Parameter | FL-DPID MPPT method | ANN-DPID MPPT method |
|---|---|---|---|
| Boost Converter | Voltage<br>Current<br>Power | 34.2 V<br>4.3 A<br>147 W | 35.6 V<br>4.45 A<br>158.5 W |
| Buck Converter | Voltage<br>Current<br>Power | 18.5 V<br>5.5 A<br>101 W | 18.8 V<br>6 A<br>110 W |
| Solar Array | Voltage<br>Current | 25.9 V<br>34.5 A | 26 V<br>35.6 A |
| | Efficiency | 93.21% | 97.11% |
| | Settling time | 45ms | 35ms |

The output voltage, current and power of buck and boost converters for ANN-DPID MPPT method are better than those obtained from FL-DPID MPPT method. These variations have been shown in the Table 2. Compared with Fuzzy logic method each and every parameter are improved in case of ANN method.

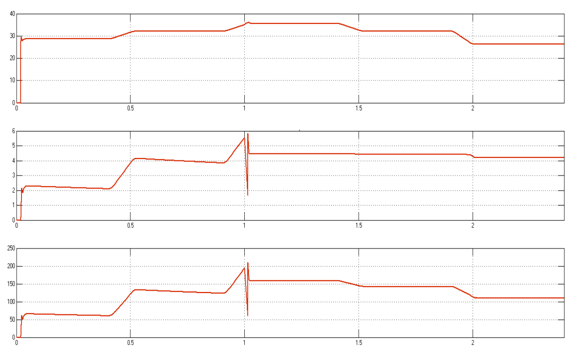

Fig7: Output Voltage,Current, Power respectively for Boost converter of ANN MPPT method



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Vol-22-Issue-4-October-December-2019

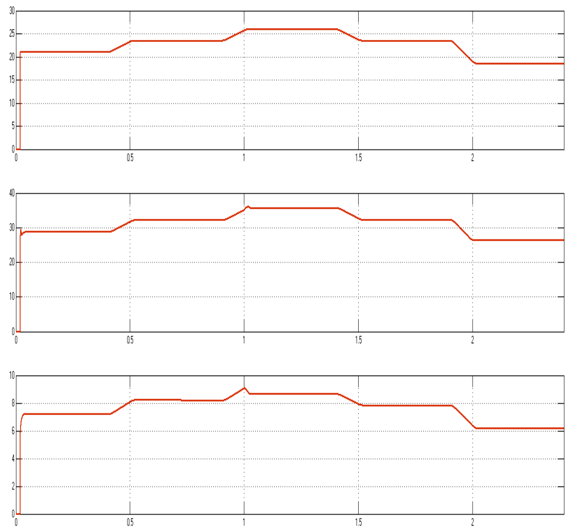

Fig8: voltage of solar panel, boost voltage, current of SPV system

Fig8 shows the SPV voltage, boosted voltage and SPV current of the system. Voltage obtained by the solar array is given to boost converter through filter capacitor, this voltage is more than the panel voltage. The main purpose of capacitor is to filter out the harmonics content from the PV array. Battery lifespan will be increased if can get constant voltage and current for the charging of battery. Otherwise due to overheating there will be more losses in battery thus efficiency in giving output would be reduced.

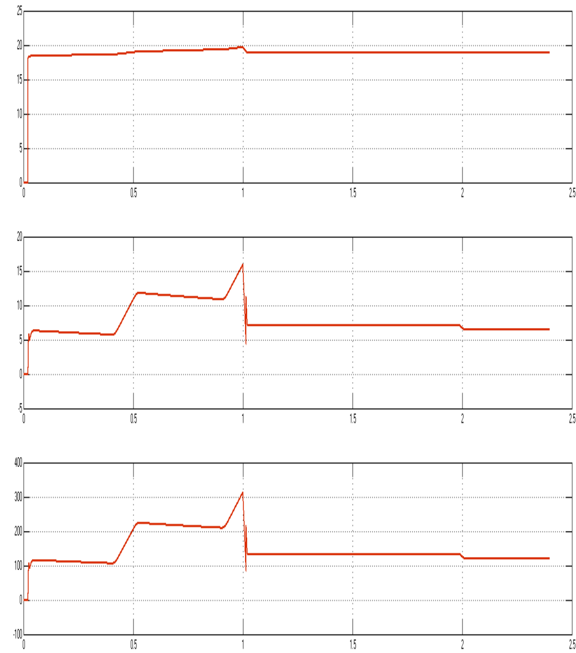

Fig9: Output Voltage,Current, Power respectively for Buck converter of ANN MPPT method

The output current, voltage, power of buck converter is represented in Fig9. The voltage of buck converter should be constant. Because buck converter output is given as input to battery for charging purpose.

## 5. CONCLUSIONS:

PV array consisting of maximum power capacity 200W is considered, implemented using simulation and results are obtained for ANN based SPV system. From the obtained results, the comparison is made and that is shown in Table2. The efficiency of FL based SPV method is 93.21%, whereas for the ANN based SPV system it is 95.11%, this shows that ANN method is giving better efficiency than FL method. Settling time is 45ms and 35ms for FL based and ANN based MPPT methods. Compared with FL-DPID MPPT method efficiency is increased, settling time has been decreased, ripple content has lowered by using ANN-DPID MPPT method. Thus, ANN-DPID method gave better performance than FL-DPID MPPT method.

## 6. REFERENCES:

[1] Adinolfi, G., Graditi, G., Siano, P., Piccolo, A., 2015. Multi-Objective optimal design of



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ISSN:0971-1260
Vol-22-Issue-4-October-December-2019

photovoltaic synchronous boost converters assessing e□ciency, reliability and cost savings. IEEE Trans. Ind. Info. 11 (5), 1038–1048.

[2] Agarwal, V., Patel, H., 2010. MATLAB-based modeling to study the e□ects of partial shading on PV array characteristics. IEEE Trans. Energy Convers. 23, 302–310.

[3] P.K. Pathak, A.K. Yadav Solar Energy 178 (2019) 79–8988.

[4] Ang, K.H., Chong, G., Li, Y., 2005. PID control system analysis, design, and technology. IEEE Transactions on Control Systems Technology. 13 (4), 559–576.

[5] Chen, Y.-T., Jhang, Y.-C., Liang, R.-H., 2016. A fuzzy-logic based auto-scaling variable step-size MPPT method for PV systems. Sol. Energy. 126, 53–63.

[6] Chen, P.-C., Chen, P.-Y., Liu, Y.-H., Chen, J.-H., Luo, Y.-F., 2015. A comparative study on maximum power point tracking techniques for photovoltaic generation systems operating under fast changing environments. Sol. Energy. 119, 261–276.

[7] Chen, B.-Y., Lai, Y.-S., 2012. New digital controlled technique for battery charger with constant current and voltage control without current feedback. IEEE Trans. Ind. Elec. 59, 1545–1553.

[8] Cheng, P.-C., Peng, B.-C., Liu, Y.-H., Cheng, Y.-S., Huang, J.-W., 2015. Optimization of a fuzzy logic control based MPPT algorithm using the particle swarm optimization technique. Energies. 5339–5345

[9] Larminie, J., Lowry, J., 2003. Electric vehicle technology explained. Wiley, Newyork. Liu, F.,Duan,S.,Liu, F.,Liu, B.,Kang, Y., 2008.Avariablestep sizeINCMPPT method for PV system. IEEE Trans. Ind. Elec. 81 (7), 2622–2628.

[10] Pode, R., 2015. Battery charging stations for home lighting in mekon region countries. Renew. Sustain. Energy Rev. 44, 543–560.

[11] Yadav, A.K., Gaur, P., 2016a. Improved self-tuning fuzzy proportional–integral derivativeversus fuzzy-adaptive proportional–integral–derivative for speed control of nonlinearhybrid electric vehicles. J. Comput. Nonlinear Dynamics 11 (6), 061013–61017.

[12] Yadav, A.K., Gaur, P., 2016b. An optimized and improved STF-PID speed control ofthrottle controlled HEV. The Arabian Journal for Science and Engineering. 41 (9),3749–3760

[13] Pawan Kumar Pathak, Anil Kumar Yadav."Design of battery charging circuit throughintelligent MPPT using SPV system", Solar Energy, 2019



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ISSN:0971-1260
Vol-22-Issue-4-October-December-2019


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