ENHANANCEMENT OF CHARGING STATION PERFORMANCE IN SOLAR POWERED EV's USING PID AND FUZZY LOGIC CONTROLLER

P. Manmadha reddy[1], Dr.Kurakula Vimala Kumar [2], D.Adinarayana[3]
[1&3]Assistant Professor, Dept.of.E.E.E, JNTUK University College of Engineering Narasaraopet, Narasaraopet Palnadu Dist
Andhra Pradesh India 522601

[2]Assistant Professor, Dept.of.E.E.E, JNTUK University College of Engineering Narasaraopet, Narasaraopet Palnadu Dist
Andhra Pradesh India 522601

Abstract

Conventional Transport system is one of the major cause of pollution and is one of the major concern in the present era. The 80-90% of the major pollutants of the atmosphere is due to the conventional transport system. With the increase in the usage of the EVs there is increase in demand of EV charging stations. There is need to design an efficient EV charging station to accommodate the rapid increase in the electrical vehicles on the road. The local grids will come under pressure and will need support from nature. The renewable sources are naturally abundant and inexpensive alternative energy sources such as solar energy will provide the best alternative to provide supply to the charging station. Due to this, highly praised renewable energy-based charging stations have recently appeared all over the world. The paper aims to provide the reader with an overview of charging electric vehicles through renewable energy along with conventional sources. An efficient charging station is designed to meet the requirements with MPPT, PID, Fuzzy logic and voltage source controller and current source controller along with a Battery management system. Maximum power point tracking controller is used for extracting maximum power from the PV module .The fuzzy logic controller can handle high voltage configuration of solar panels to help to reduce voltage drop and enhance the efficiency of the charging station by increasing the output power and decreasing the charging time. The design of charging station is formulated and validated in MATLAB Simulink.

1. INTRODUCTION

With the increase in the Green House Gases and the fossil fuels endangering our planet the government all over the world is creating awareness and providing subsidies to the customer Conventional Transport is consuming the major part of the non-renewable sources which is endangering the fossil fuels for the future generation. Electric vehicles can reduce GHG emissions by half in 2030 compared to fossil fuel driven cars, offsetting up to 540 Megatons of CO2-equivalents.

Electrified cars also significantly reduce air pollution. Electrified cars made up just 0.4% of the cars on the road in 2018. By 2030, the share of electrified vehicles of new sales could be as high as 50%. But it could also be only 10%. According to NITI Aayog's energy policy report, India's demand

for energy is expected to double by 2040, and that for electricity to potentially triple as a result of increased ownership of electric vehicles developed for this application. The exchange of data between the station, the vehicle and the supervision systems takes place through a networking system using zigbee modules. In paper [2], The metrological data are measured in Al Baha University at Saudi Arabia to determine the optimal design of PV panels to operate the EV. The topology and sizing of each component of the system are provided in this paper. The simulation results show that the modified EV could decrease the environmental emissions of Co2 by 420 Kg per year. The modelling and designing of the developed PV system involve several procedures such as evaluating the dynamic load demand, analyzing the power performance, and optimizing the size of PV system. In paper [3], This paper made an effort to offer a framework for the design and development of a solar charging system, giving authors the chance to gain knowledge of solar energy's theoretical underpinnings and practical applications. The suggested solar charging system will be one of the steps done to make the campus environmentally friendly. According to the proposed system's economic analysis, the project's payback period is 3.5 years. In paper [4], In order to concurrently reduce pollutant emissions from the power generating and transportation sectors, this study creates a model that integrates solar power plants and electric vehicles (EVs). This study applied the approach to Shenzhen City, which has the most EVs in the world, to confirm its technical and financial viability. The output of the modelling revealed that the COE of the combined energy system is

$0.098/kWh, while the NPC of a PV power charging station that can satisfy the electricity demand of 4500 kWh is $3,579,236. As a result, this approach is suitable from an economic perspective. Also, this model shows a great potential for reducing pollution emissions. In paper [5], In order to efficiently charge electric vehicles while keeping in mind the necessity to move to renewable energy sources, the charging station prototype was built using a hybrid power supply. This will be used to charge cars sustainably in light of recent advancements in the sustainable transportation sector. There must be adjustments made to the battery capacity in order to shorten the charging time. It is necessary to utilize a battery with greater ampere-hour standards. In paper [6], The current has a few drawbacks, including the fact that it is less effective on overcast and wet days and that solar energy is lost during the transfer of power. In paper[7], In the proposed work ,an optimal approach for the design of EV charging station powered by solar panels and storage of battery management system and a supplement of grid for the charging of the EV vehicle. In paper [8], BESS will store the excess energy from the solar panel and gives it back to the load during excess requirement. The solar PV panels act as the main source of energy supply to the charging station. We know that the power from the solar panels is not available in the dark and cloudy conditions, there will be an interruption in the power supply in such conditions. In paper[10], To provide a continuous supply of power for the charging station grid supply is given to the charging station. Whenever there is a deficiency of the power in the charging station the supply will be provided by the BESS and if the BESS is not able reach the peak demand the grid will supply the power to the charging station. With the above process we can ensure the continuous supply of power in the charging station.

2. Simulation Using MPPT and PID Controller

2. 1 Block Diagram

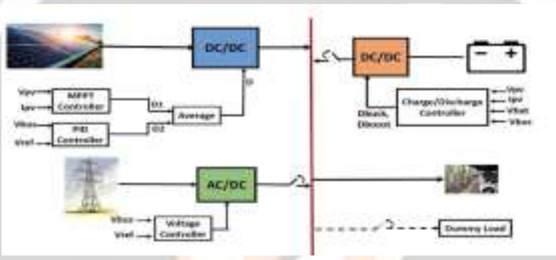


Figure1: Block Diagram with PID Controller

2.2 Simulation Diagram

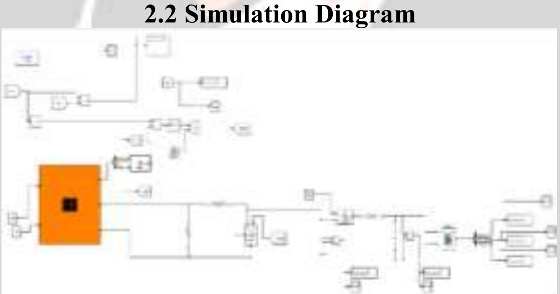


Figure2: Simulation Diagram using MPPT and PID Controller

2.3 Control Methodology

A maximum power point tracker (MPPT) is used in this system to track the maximum power of the solar panel. This system uses the P&O method. The operating point is continuously increased until the maximum performance point is reached. Once the maximum power point is found, the power is extracted. The same process repeats as the power increases. Otherwise, the disturbance is reversed. Here we use a PID controller to keep the intermediate circuit voltage constant at 48 V. The DC bus voltage is measured, factored by the voltage of interest and the resulting error fed to his PID controller.

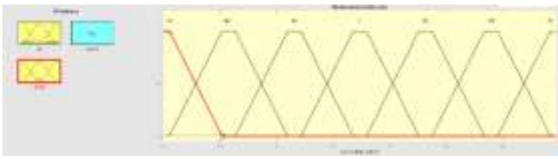
3. Simulation using Fuzzy Logic and MPPT Controller

Fuzzy logic theory provides deeper control and offers range to point or range to range control. FLCs are based on multivalued reasoning and use approximations rather than defined and precise values. IF-THEN rule is used in fuzzy logic. These
controllers are ideal for multivariable, inconsistent processes where it is challenging to precisely assess input and its effect. Depending on the application, FLCs can have one or more inputs and outputs. The FLC's control algorithm makes use of linguistic or qualitative data. As a result, it gets around the challenge of clear information in terms of numerical values.

i. Rule Base: provides guidelines and IF-THEN conditions that professionals have made possible to direct the decision-making mechanism based on linguistic data. Several effective techniques for creating and fine-tuning fuzzy controllers are now available thanks to recent advances in fuzzy theory. The majority of these innovations lower the quantity of fuzzy rules.

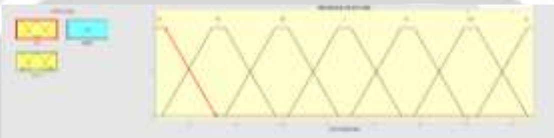
ii. Fuzzification: This process transforms inputs, such as sharp numbers, into fuzzy sets. Crude inputs, which include things like temperature, pressure, and rpm, are essentially exact inputs that are measured by sensors and processed by the control system.
iii. Inference Engine: It assesses the degree to which the current fuzzy input matches each rule, and then chooses which rules to apply based on the input field. Then, control functions are created by combining the triggered rules.
iv. Defuzzification: This is used to convert the fuzzy sets received by the inference engine into a sharp value. Several defuzzification methods are available, the most suitable one is used to reduce the error with a specific expert system.

3.1 Fuzzy Rule Base



Input 1

3.2 Fuzzy Inputs



Input 2

3.3 Block Diagram

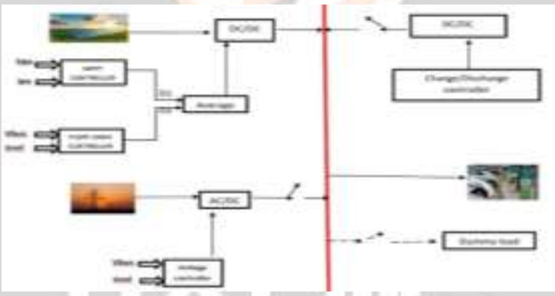


Figure 3: Block Diagram with Fuzzy Logic Controller

3.4 Simulation Diagram

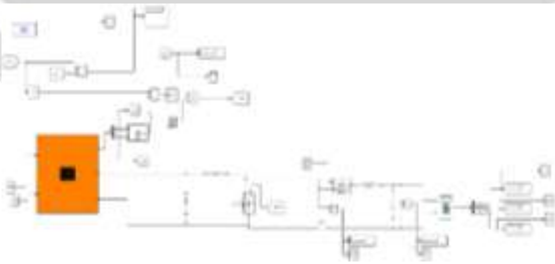


Figure 4: Simulation diagram with Fuzzy Logic Controller

4. EV as a Load

$$SOC_r = SOC_{lt} - SOC_C$$

SOC_{lt} is the user specified SOC limit
SOC_C is the SOC already Charged
SOC_r is the required SOC that is to be charged

$$E_{ev} = \frac{(SOC_r \times V_{ev} \times Ah)}{100}$$

V_{ev} is the voltage rating of battery
Ah is the Ampere-hour rating of battery
E_{ev} is the Energy required by the battery's

	NB	NM	NS	Z	PS	PM	PB
NB	NB	NB	NB	NB	NM	NS	Z
NM	NB	NM	NM	NM	NS	Z	PS
NS	NB	NM	NS	NS	Z	PS	PM
Z	NB	NM	NS	Z	PS	PM	PB
PS	NM	NS	Z	PS	PS	PM	PB
PM	NS	Z	PS	PM	PM	PM	PB
PB	Z	PS	PM	PB	PB	PB	PB

$$\boldsymbol{P_{ev}} = \frac{\boldsymbol{E_{ev}}}{\boldsymbol{h - t}}$$

h is the user specified time limit
t is the time already covered for present SOC
P_{ev} is the Power requirement of that EV battery

$$P_{tot} = \sum P_{ev}$$

P_{tot} is the total power requirement of the EV station
P_{ev} is the power requirement of the EV

4.1 Using PID and MPPT Controller

Let us assume there is one EV vehicle of rating 72V, 60Ah is to be charged from 20% to 100% charging, with the power availability of 1.4KW.

Calculations

$$SOC_r = SOC_{lt} - SOC_C$$

=100-20
= 80

Total energy required (E_{ev})
$= \frac{(SOC_r \times V_{ev} \times Ah)}{100}$
= (80*72*60)/ 100
= 3,456 Watt-hour
= 3.456 KWh

Time to charge battery (t) = % * time taken to full charge
t = 20% (90)
t = 18min or 0.3 h
P_{pv}=1.4kw

Total time required to charge 0 to 100%
$= E_{ev} / P_{pv}$

= 3.456 / 1.4
= 2.4hrs

Time required to charge 20 to 100%
= 80% of (2.4hrs)
= 1.9hrs

4.2 Using Fuzzy Logic Controller and MPPT Controller

Let us assume there is one EV vehicle of rating 72V, 60Ah is to be charged from 20% to 100% charging, with the power availability of 2.88KW.

Calculations

$$SOC_r = SOC_{lt} - SOC_C$$

=100-20
= 80

Total energy required (E_{ev})
$= \frac{(SOC_r \times V_{ev} \times Ah)}{100}$
= (80*72*60)/ 100
= 3,456 Watt-hour
= 3.456 KWh

Time to charge battery (t) = % * time taken to full charge
t = 20% (90)
t = 18 min or 0.3 h
P_{pv}=2.7 KW

Total time required to charge 0 to 100%
$= E_{ev} / P_{pv}$

= 3.456 / 2.7
= 1.28 hrs

Time required to charge 20 to 100%
= 80% of (1.28hrs)
= 1 hr

5. Comparison Between Controllers

Calculation of the PID control equation is complicated by the interaction of multiple variables and constants**.** In many cases, it can take some time for the output to respond to changes in the input. If the target value changes quickly, the PID forces the system to apply a large correction factor, which can result in overshoot. Or the system may become saturated and not provide enough compensation. Tracking slow set point changes can cause problems for PID control systems. As a result, choosing the optimum value is something of a trial-and-error process called "tuning". Many approaches to tuning have been developed over the years, of which the "Ziegler Nichols" method seems to be the most satisfactory**.** However, this creates strong vibrations, which can be a problem in some situations.

Fuzzy controllers are more flexible than PID controllers because they have more parameters (type and membership function parameters in the fuzz and defuzzification modules) to modify the control surface. This makes them useful for non-linear control plants. I agree that fuzzy controllers are easy to implement, but relatively difficult to configure, i.e., what member functions are needed, how to set their parameters. Fuzzy controllers are easy to understand because of their rule base, but only if there are few linguistic variables. In any case, fuzzy controllers are useful in any control system with a strong nonlinear device, where a small change in the manipulated value changes the parameters of the device or even its dynamics. The fuzzy controller maintains excellent reference tracking, while the tuned PID provides reasonable response but with overshoot. Thus, a certain part of the reliability of the PID controller is lost, so it is necessary to reconfigure it. Thus, the robustness of FLC is better than that of PID tuned for this application.

6. Comparison between outputs

State of Charge (SOC)	Time taken to charge from SOC to 100% using PID and MPPT Controller	Time taken to charge from SOC to 100% using Fuzzy Logic and MPPT Controller
20%	1.9 hrs	1 hr
40%	1.44 hrs	0.76 hrs
60%	0.96 hrs	0.512 hrs

Table No.1

The output of PID Controller from the solar panels is 1.4kw which can charge the electrical vehicle of 72v and 60Ah from 20% to 100% in 1.9hrs.

For the same solar panels, the output from the fuzzy logic controller is 2.7kw which can charge the same electrical vehicle of 72v and 60Ah from 20% to 100% in 1hr.

From the above results we can say that the output power of fuzzy logic Controller is more than the output power of the PID Controller.

In the Busy world, where time is the major constrain, the usage of electrical vehicles will only be increased if the charging time in the charging station is decreased using the better control methodology. But we cannot decrease the time by taking the power from the grid, which is not economical. So, In the proposed work a solar powered EV charging station is designed to charge a EV in minimal time.

7. Result Analysis

7.1 Output from PID and MPPT Controller

Figure5: Output voltage with PID and MPPT Controller

Figure6: Output power with PID and MPPT Controller

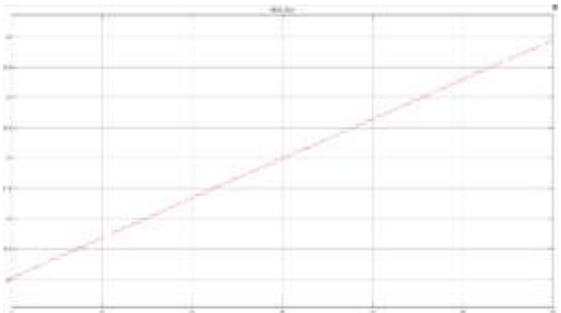


Figure7: State of Charge with PID and MPPT Controller

7.2 Outputs of Fuzzy Logic and MPPT Controller

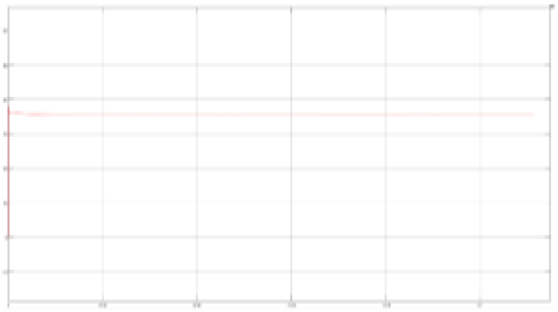


Figure8: Output Voltage with Fuzzy Logic and MPPT Controller

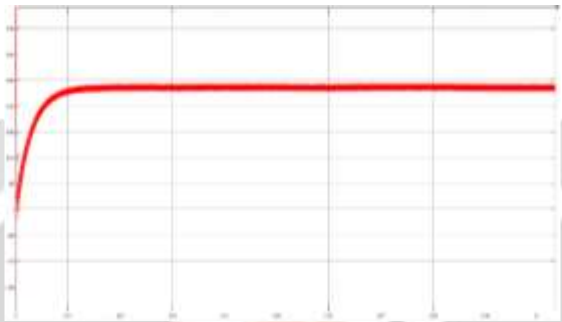


Figure9: Output Power with Fuzzy Logic and MPPT Controller

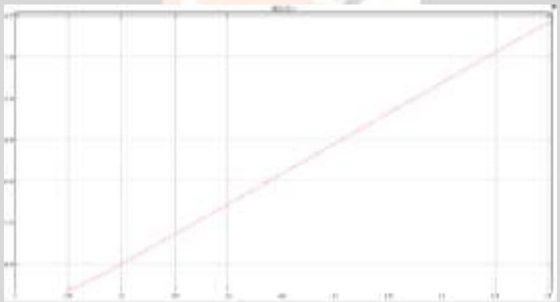


Figure10: State of Charge with Fuzzy Logic and MPPT Controller

8. Conclusion

As the number of EVs on the road rises, charging them has become a crucial problem. A charging station equipped with solar panels, a battery storage system, and additional grid assistance offers a promising alternative for meeting the daily charging needs of all connected EVs. But to design an efficient Charging station the inclusion of controllers is necessary. In this paper an attempt is made to compare the outputs of both the fuzzy logic and PID controllers and analyzed for the time efficient charging station. Hence, the comparison of the controllers shows that controllers can increase the output and Fuzzy Logic controller along with MPPT can provide time efficient charging when compared to PID controller along with MPPT Controller. From the above discussion we can conclude that Fuzzy logic controller can provide better efficiency in the charging station than the PID controller.

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