Constant Current Adaptive Neuro Fuzzy Inference System Controller for Grid Connected Electric Vehicle Charging

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Abstract –

The large number of automobile in use around the world has caused and continues to cause serious problem of environment and human life. Air pollution, global warming and rapid depletion of the earth's petroleum resources are now serious problem due to climate change and high dependence on fossil fuels in the transport sector most of the countries have created new and more demanding laws to regulate and control issues related with CO, Carbon dioxide and NOx emission. The electric vehicle has important role to fulfil this demand. Electrification of the transport sector can also bring benefits in term of increased energy efficiency and reduced local pollution. Electrical Vehicle (EV) offer an opportunity to replace fossil fuels in the transport sector. But several issues still pose barrier to the widespread adoption of electrical vehicle. The fast charging will be key in the future .As a result, there is a clear need for EV charging times to be shortened. Electric vehicle (EV) charging at a constant current with ANFIS can assist in resolving this issue. So DC-DC converter plays a crucial role .The prospect of grid-connected constant current charging of Electric Vehicles using a buck DC-DC converter and an Adaptive Neuro Fuzzy inference System (ANFIS) controller is discussed in this research . ANFIS is simple to set up and does not necessitate extensive mathematical modelling. The entire model of the system under consideration was developed in MATLAB/Simulink. The simulation results suggest that the proposed strategy is viable and capable. Thus, the system has been simulated and tested on MATLAB/Simulink.

Key Words: Adaptive Neuro Fuzzy inference System (ANFIS), DC-DC converter, Electric Vehicle(EV).

1. INTRODUCTION

Energyisakeytohumandevelopment,andrenewable energy can ensure energy needs are met whileprotecting local environments and populations. Even othersources of energy are finite and will someday be depleted.Now a day's renewable energy is the major source for thepowergeneration.Electric vehicle makes revolution in future because this does not produces harmful gases. Currently due to increase in rate of petrol, public also going for electric vehicle and favorable to environment .But there are some obstacle in electrical vehicle as distance range ,battery backup ,lack of charging station and charging time ..An electric car takes as little as 30 min or more than 12 hours to charge..Currently, a lot of research work is going on regrading Electrical Vehicle charging process through power grid connection. Decrease in charging time is an important requirement in making EV easy to use. As a result of this, fast DC and constant current (CC) charging systems offer a fascinating opportunity.

A comprehensive review of fast charging with the fuzzy logic controller. A fast charging of EV is implemented with a bang-bang control. Bang-bang control system automatically turns on/off in order to keep the measured output close to reference value. DC bus connection is more important because it needs lesser switching process, small volume, low electromagnetic inference, and increaseefficiency however almost all DC-DC converter topologies can be bidirectional which is useful in regenerative braking. The constant current charging method adjusts the output voltage of charging devices. The incorporation of a well-defined Electrical Vehicle (EV) fast charging in the smart grid can offer numerous potential opportunities, particularly from the perspective of vehicle to grid technology as well as a solution to the renewable energy intermittency issue. This work reviews the state of the art technology for the fast charging of electric vehicle with coverage of the research work done related to the challenges and roadblocks to be encountered in its implementation.

This paper focuses on buck DC-DC converter charging of grid connected electric vehicles with constant current Adaptive Neuro fuzzy Inference System. All connection of grid as well as battery has been used in MATLAB/Simulink for the analysis of the complete Electrical Vehicle charging system. ANFIS is more efficient it has uses in intelligent situational aware energy management system. It is moreeasy to implement than Fuzzy Logic Controller (FLC) because it integrates both neutral networks and fuzzy logic principal; it has efficiency to to capture the benefit of both in single frameworks.

II. DESIGN OF ELECTRICAL VEHICLE CHARGING SYSTEM

The complete simulation is developed in MATLAB/Simulink which is shown in fig. 1.

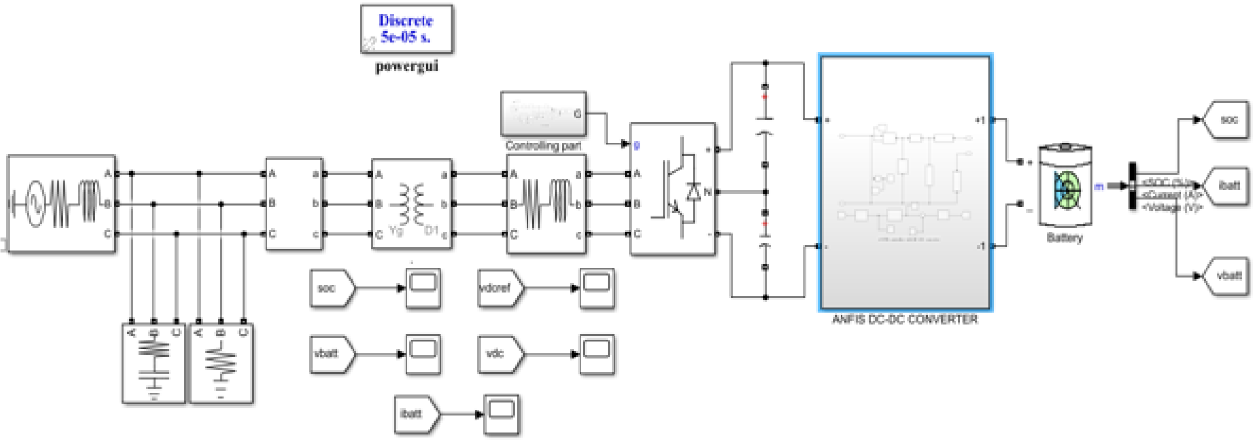

Fig.1.EV charging system development in MATLAB/Simulink

According to figure, the grid is connected to the *three phase voltage source and transformer as a* Star-Delta connection and the Star- Delta transformer provides step down voltage to the three- level bridge inverter .A three level bridge inverter is used for AC to DC conversion. The DC bus voltage and reactive current is adjusted by the control system, DC regulator. DC regulator comprises of a DC bus voltage control and a current control. The Idref is the output of the DC voltage regulator. .A d-q transformer is used with phase loop. The output of the inverter is connected to DC bus. The input of DC-DC buckconverter is connected to the output of the grid supply

.DC-DC buck converter permits the steps down of input voltage magnitude to a desirable level in order to charge the Electric vehicle (EV). The output of the converter is connected to the battery, which is shown in fig.4. The duty cycle of the buck converter is the ratio of the output voltage and input voltage which can be determined as :

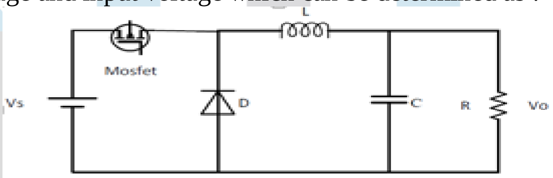

Fig.2. DC-DC buck converter

Duty ratio(D)=$\frac{Vo}{Vi}$

As the duty cycle D is equal to the ratio between t_{on}

And the time period T, it can not be more than 1.

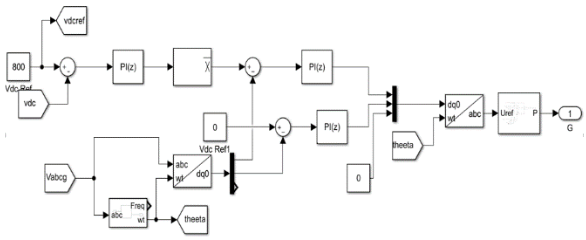

Fig.3. DC regulator

Therefore, VO ≤Vi .$R$and$f$ are the resistance and switching frequency respectively. So for continuous operation

VO=D

The output current delivered to the load (I_O) is constant, as considered that the output capacitor is so large enough to maintain a constant voltage across its terminal during commutation time

I_L=I_o

whereI_L is the average value of inductor current which is continuous current.

$I_L = \frac{Vo}{R}$

III. Adaptive Network based Fuzzy Inference System (ANFIS):

ANFIS network are typically based on clustering a training set of numerical samples of the unknown function to be approximated. ANFIS network have been successfully applied to classification tasks, rule based process control,pattern recognition and similar problems. Here a fuzzy inference system comprises of the fuzzy mode.ANFIS networks have been successfully applied to classification tasks, rule-based process control, pattern recognition and similar problems.Here a fuzzy inference system comprises of the fuzzy mode.This method selects the important input variables when building a fuzzy model from data by combining cluster estimation method with a least squares estimation algorithm. The method follows in two steps :i) First step involves extraction of an initial fuzzy model from input output data by using a cluster estimation method incorporating all possible input variables. ii) In the next step the important input variables are identified by testing the significance of each variable in the initial fuzzy model.Fig.4 shows the implementation of the adaptive neuro fuzzy inference system and difference between the reference and the actual voltage which is serves as input for the controller and input of the controller

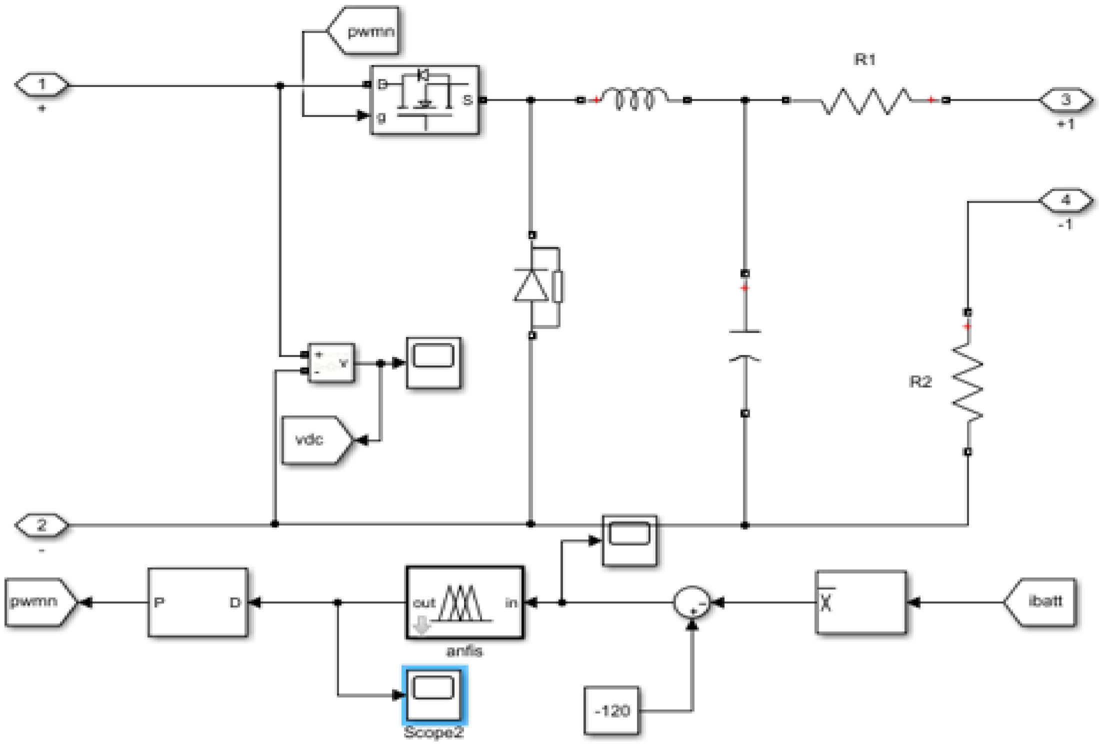

Fig.4.Adaptive neuro fuzzy logic controller with DC-DC converter

is given to the pulse width modulation (PWM).This modulator generates the switching frequency. Fig.5 shows the structure of the adaptive neuro fuzzy

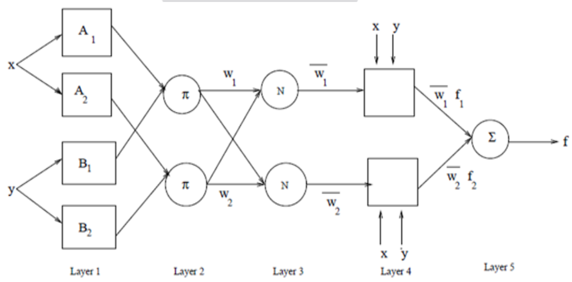

Fig.5 ANFIS structure

Inference system proposed by Takagi and Sugeno is used. In this inference system the output of each rule is a linear combination of the input variables added by a constant term. The final output is the weighted average of each rule's output. In this inference system the output of each rule is a linear combination of the input variables added by a constant term. The final output is the weighted Average of each rule's output. The fifth layer comprises of only one fixed node that calculates the overall output as the summation of all incoming signals, that given as

O_i^5=overall output=$\sum_i Wifi = \frac{\sum_i wifi}{\sum_i fi}$

Wherewith is the output of Layer 3 and where f_i islinear in the consequent parameters.Membership functions are used to describe fuzzy sets which denotes the degree of accuracy and its value lies between 0 to 1.ANFIS reduces the distortion in constant current and battery voltage magnitude and improve the power quality with the help of pulse width modulation and provides the constant current magnitude for charging the electrical vehicle.There are two rules of membership function representation:

1. If the input MF is low input (LI) then output MF is also low (LO).
2. If the input MF is high input (HI) then the output MF is also high(HO).

The input-,outputmembership function and crispy output is shown in fig.6, 7, and 10 and fig 8, 9 shows the input –output of the rules viewer.Proficiency is described by fuzzy inference sets combined using rules and when all of this information is considered into account a call made.

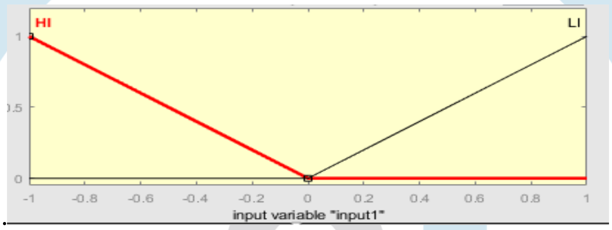

Fig.6.Input membership function.

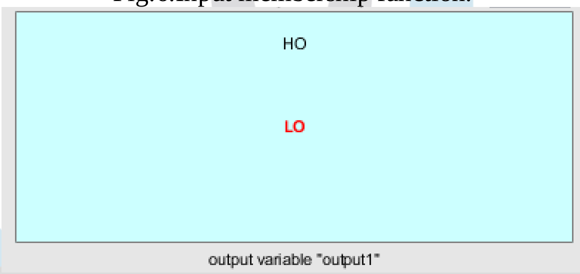

Fig.7.Output membership function.

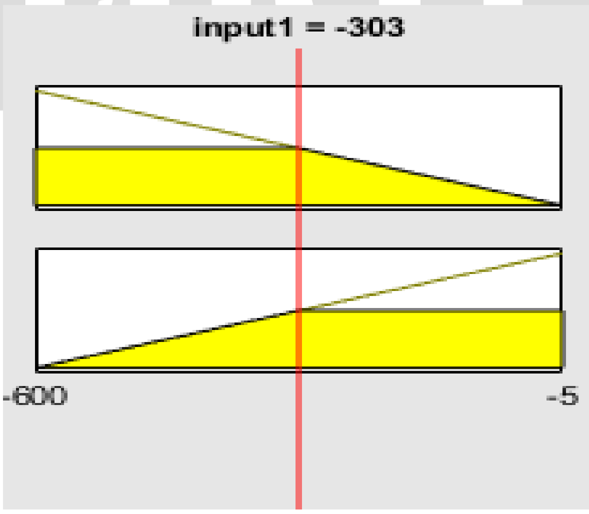

Fig.8.Input in rules viewer

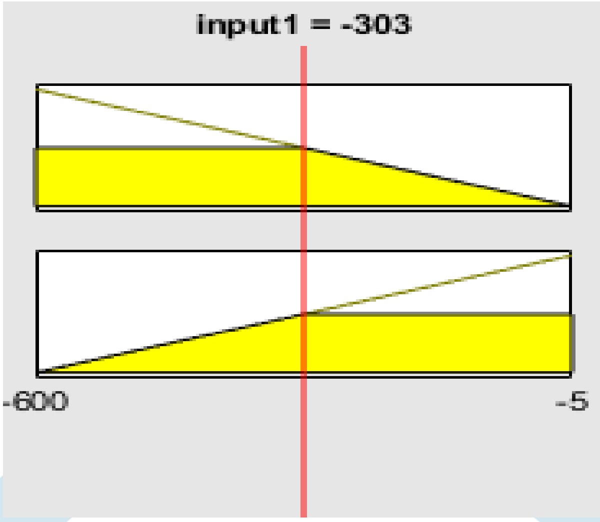

Fig.9. Output in rules viewer

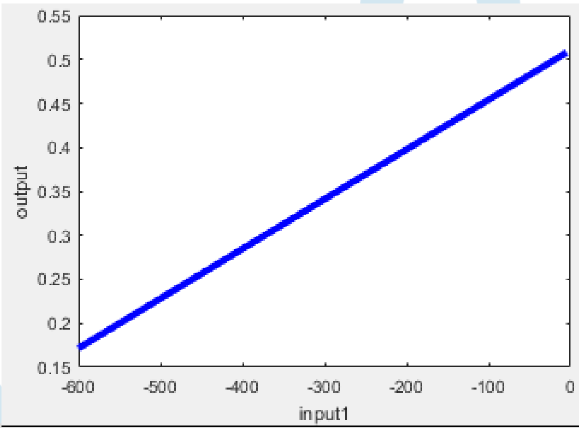

Fig.10. linear output function

IV. SIMULATION RESULTS

The value of the design parameter is shown in table1.

Grid voltage	600 V
Grid frequency	60Hz
Transformer	600/240V
Inductance	21µH
DC bus voltage	800V
Battery state of charge	50%
Battery time constant	2 sec
Battery nominal voltage	300V
Battery capacity	12KWh
Short circuit level	300MVA
EV charging current	120A

The values of the parameters are used for the simulation. The grid voltage is 600volt and frequency is 60Hz .The transformer has 600/240 V as voltage ratio and DC bus voltage is 800V. The battery state of charge is 50% and battery time constant is 2 sec. there is a steady rise in battery state of charge (SOC) from 50% while maintaining a constant DC voltage as shown in Fig 13.

Fig.12 shows the result for the 120A constant current charging for the 12 kWh EV battery. In EV battery, FLC maintains constant current for charging. This result shows the suitability of the FLC for fast DC charging of EV. When battery charges at constant current, the charging voltage will always be exceeding the open circuit voltage of 324V.
The adaptive neuro fuzzy inference controller maintains the constant magnitude of charging current for the charging of battery.

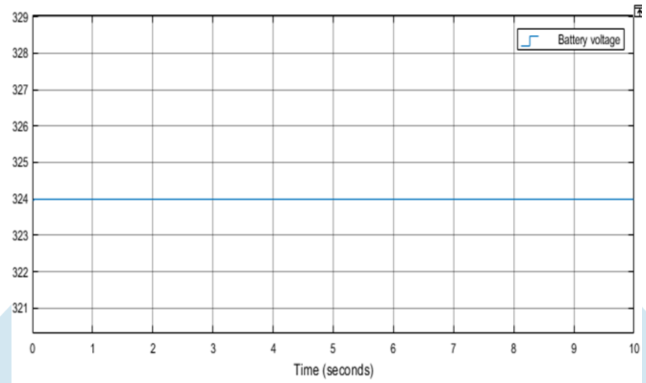

Fig. 10. Battery voltage

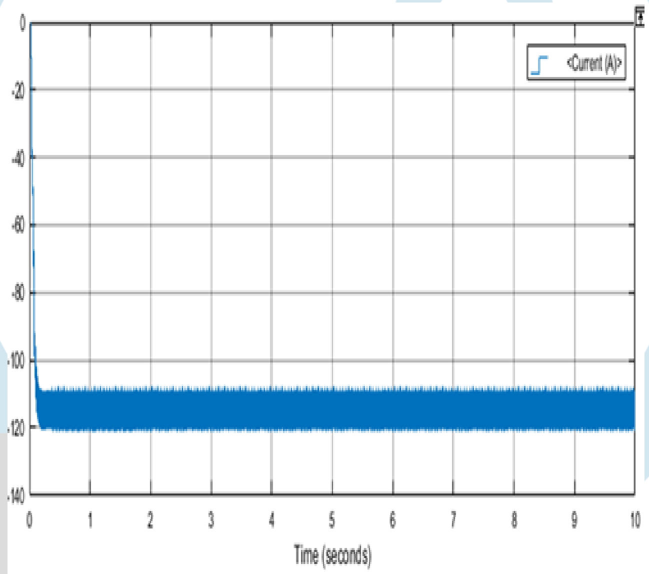

Fig. 11. Battery current

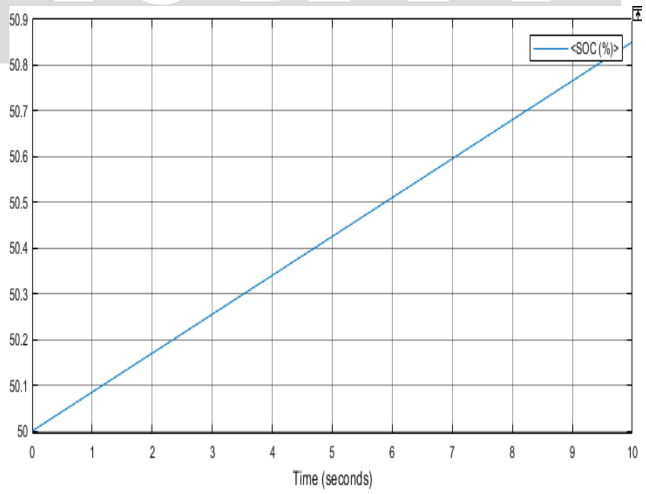

Fig.12. State of charge

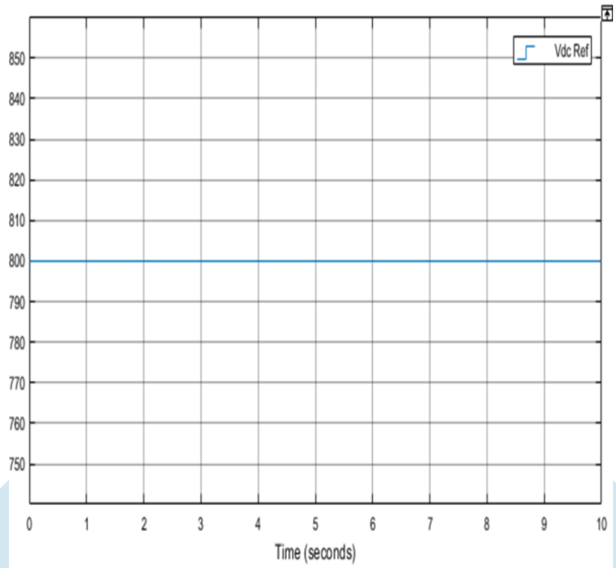

Fig.13.Reference DC voltage

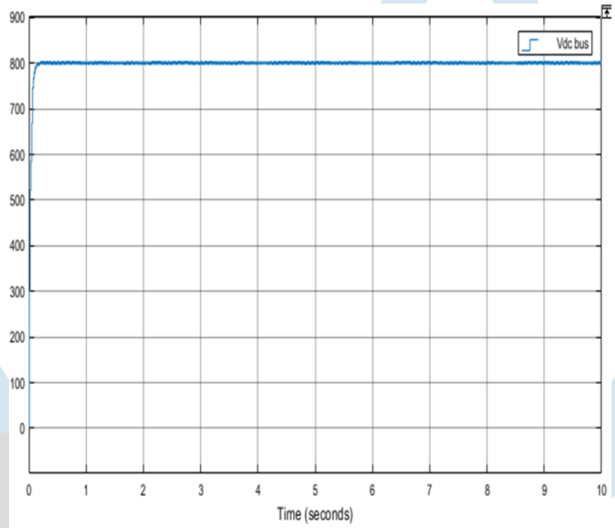

Fig. 14.DC bus voltage

CONCLUSION

In this paper, the achieved simulation results show how ANFIS can be easily used in electrical vehicle chargingwithout using any PID controller. The complete model of electrical vehicle charging with adaptive neuro fuzzy logic controller has been developed in the MATLAB/Simulink. MATLAB/Simulink software was used to evaluate the simulation findings in the context of this investigation.

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