DESIGN AND DEVELOPMENT OF DIFFERENT TOPOLOGIES FORFAST EV CHARGER

REKHA C M [1], ARUNKUMAR[2], SANJANA[3], SHASHANK G MADIVAL[4], SRINIVAS G[5]

[1]Assistant Professor, [2,3,4,5]Students
Dept. of EEE,
Acharya Institute of Technology, Bangalore

Abstract- **The Government of India hopes to have a country with 100% electric vehicle mobility by the year 2030 in order to create a clean, green environment and minimize carbon emissions. Infrastructure and quick charging stations are apparently necessary if there are to be such a big number of electric vehiclesoperating on Indian roads. In this project, various rapid charging topologies for electriccars are presented. The paper describes the development and the comparison of differenttopologies for fast EV charger. In our project weare using bidirectional DC-DC converter that is dual active bridge (DAB) for the fast charging**

Keywords- **Mobility, Carbon emission, ChargingTopologies, bidirectional DC-DC converter, DAB.**

INTRODUCTION

The rechargeable battery is one of the crucial and complex systems that provides electricity to drive electric vehicles (EVs). Therefore, having an effective, trustworthy, and affordable battery charger is crucial forEVs. To fully satisfy the requirement, an AC-DC converter is required. [5], [6], [7], [8], [9].

Electric vehicles powered by batteries are becomingincreasingly popular around the world. Several causes are driving this trend, including the need to reduce air and noise pollution and reliance on fossil fuels.[2] Bidirectional DC-DC converters are required for high power density, high efficiency Power ConversionSystems with High Frequency tie connection are most likely to be used due to the increased need for quick battery charging. High Frequency Power ConversionSystems central circuit is called a Dual Active Bridge (DAB). Numerous different topologies for isolated, bi- directional DC/DC converters have been previously described. [10] High-power DC/DC converters come in four main topologies: LLC resonant converter, Phase- shifted Full Bridge, Single-phase Dual-Active Bridge, and Dual-Active Bridge in CLLC mode (DAB - CLLC).[3]

One of the finest circuits for a quick EV charging is DualActive Bridge (DAB). One of the potential isolated DC/DCconverter topologies that will be crucial in the future integration of electric vehicles (EVs) in smart grids is the dualactive full bridge (DAFB). This is as a result of its built-ingentle switching and straightforward control. [4]

There are many number of control strategies for fast charging of Electric vehicle batteries for example PI, FUZZY, Advanced PI, ANFIS, AI etc. But in this project, we proposed the idea of ANFIS and PI control strategies for fast EV charger.

In order to reduce charging time for the specified lithium-ion battery system, a DC-DC converter with a modified PI controller has been proposed in this study. Ithelps to obtain the needed output voltage and high current density with barely perceptible overshoot. Inaddition to reducing the power loss of the active switches, the suggested approach lowers the junction temperature, extending the converter's lifespan.[11]

In our project we have shown the circuit diagrams and demonstrated the simulation circuit and result of both thecontrol strategies. ANFIS Controller gives better performance when compared with PI Logic Controller.

CIRCUIT DIAGRAM

A. Dual Active Bridge (DAB)

Future autos will require more electric power, which willincrease the demand for bi-directional isolated DC/DC converters to move energy between various voltage ratios, such as those between the high-voltage drive trainand the low-voltage accessories. Such converters may also be utilised in future, all-electric aeroplanes, where they will serve as the interface between the aircraftpower distribution system and certain loads Dual Active

Bridge is one type of the DC-DC converter that works onthe isolated charging type and it is more efficient compared with other type of DC-DC converter [12].

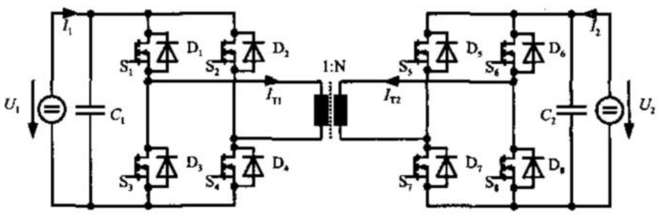

Fig 1. Single phase dual active bridge.

This converter may produce an output voltage that is either greater or lower than the converted input voltage, which is the input voltage multiplied by the transformerturns ratio, depending on the control. Since bidirectionalpower flow is available in both

scenarios, the operating mode is referred to as step up or step-down operation.
The leakage inductance L is used by the dual active bridge converter (Fig. 1) as a buck or boost inductor to span the appropriate output voltage range. Leakage inductance is used with a capacitor in series to create a series resonant converter, which can function with bidirectional power flow over a broad range of input andoutput voltages.
This single phase dual active bridge consist of 2 B2C bridges as shown in fig 1 at the input and output side of transformer. The transformer's leakage inductance servesas the power transmission component. The rms transformer current depends on *d*, *L0*, and the phase shiftangle ϕ between the input and output bridges while ignoring copper and switching losses. And it can be derived as

$$I_{i,T,rms} = \frac{\sqrt{3}}{6}\cdot\frac{V_i}{\omega L_\sigma}\cdot\sqrt{\frac{1}{\pi}\cdot(d^2\pi^3+12\Phi^2 d\pi-2d\pi^3-8\Phi^3 d+\pi^3)}$$

The input power is equivalent to the output power once losses are considered, and it may be computed using

$$P_i = P_o = \frac{V_i^2}{\omega L_\sigma}\cdot d\Phi\cdot(1-\frac{\Phi}{\pi})$$

B. Proportional Integral (PI)
Due to its numerous benefits, PID (Proportional-Integral-Derivative) controllers are still the most popularcontroller architectures used in control loops today. Since the control process is noisy, the derivative effect isnot frequently applied. The majority of the time, PI(Proportional-Integral) controllers are favoured over PIDcontrollers. According to reports, PI controllers make up the majority of PID controllers used in industrial applications. In most control systems, PI controllers deliver good performance despite having two parametersthat must be determined. [14]

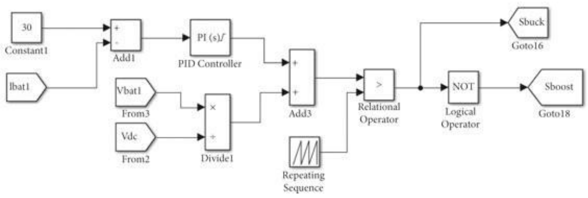

Fig 2. Control Circuit for PI Controller

C. Adaptive Network based Fuzzy Inference System(ANFIS)
The foundation of an ANFIS network is often the clustering of a training set of numerical samples representing the unknown function to be approximated.
Applications of the ANFIS network to categorization jobs, rule-based process management, pattern recognition, and other issues have proved effective. Here, the fuzzy mode is part of a fuzzy inference system.Application of ANFIS networks to categorization jobs, rule-based process management, pattern recognition, andother issues has proved effective. Here, the fuzzy mode is part of a fuzzy inference system. When creating a fuzzy model from data, this technique chooses the crucialinput variables by fusing the cluster estimation method with the least squares estimation algorithm. [13]

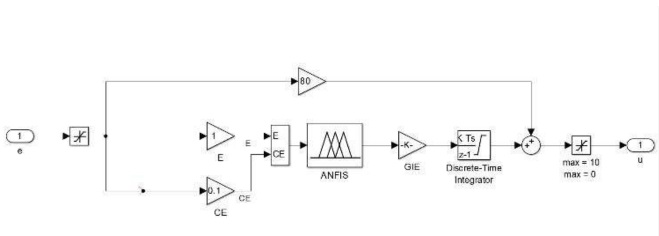

Fig.3 Control circuit for ANFIS

SIMULATION CIRCUIT

A. DAB Using PI Control Logic
An electric vehicle (EV) charger that charges quickly generally converts a Single-phase AC input into a DC output. PI control logic may be applied to regulate the charging procedure and guarantee that the battery ischarged effectively and securely. Based on the discrepancy between the planned output and the actual output, the PI control logic modifies the charger's outputvoltage and current.
Here are the basic steps for implementing PI controllogic in a fast EV charger:

1. Utilize sensors or meters to measure the voltageand current of the battery.
2. To determine the error, compare the measured values to the desired values.
3. Based on the inaccuracy, determine the output voltage and current using a PI controller. To provide a steady and accurate reaction, the PI controller utilizes a prportional term to adapt tothe present error and an integral term to respondto previous mistakes.

4. To modify the charging procedure, the power electronics of the charger should be supplied with the predicted output voltage and current.

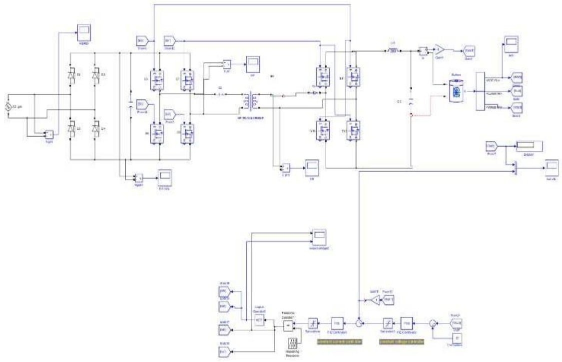

Fig 4. Simulation circuit of DAB using PI Controllogic

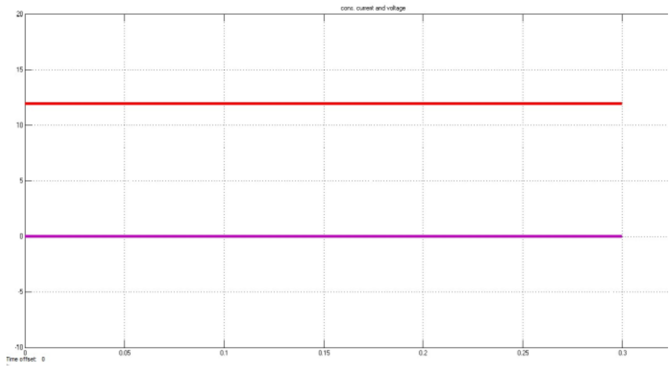

Fig 5. Current and voltage waveforms

DAB Using ANFIS Control Logic

Artificial intelligence (AI) of the ANFIS (Adaptive Neuro-Fuzzy Inference System) variety combines theflexibility of neural networks with the transparency offuzzy logic. ANFIS may be used to regulate differentelements of the charging procedure, including the charging rate, voltage, and current, in the context of arapid EV charger.

In order to adapt the charging settings in response to these inputs, the ANFIS system combines neural networks and fuzzy logic. Utilising previous data, neural networks are utilised to forecast the ideal charging parameters based on current inputs. Based on these predictions, rules are generated using fuzzy logic, and the charge parameters are changed in real-time.

The ANFIS control logic is an innovative technologythat, by reacting to changing conditions and customising the charging process for each car, may assist increase the effectiveness and dependability offast EV chargers.

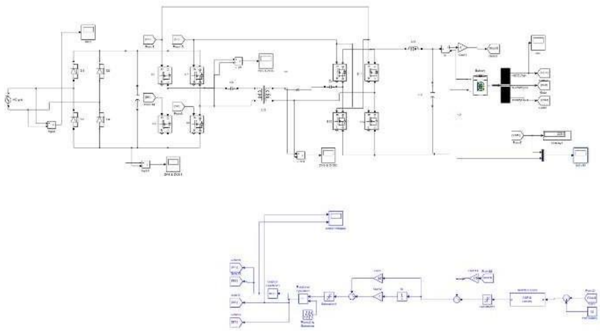

Fig 6. Simulation Circuit of DAB Using ANFISControl Logic

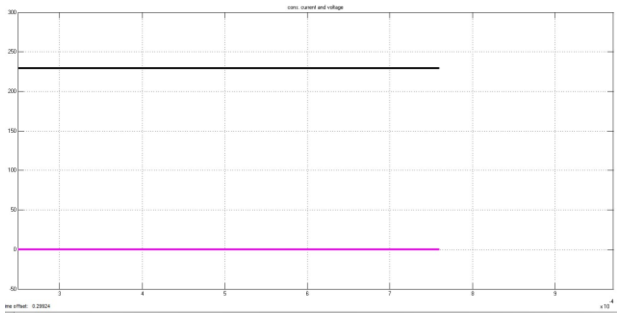

Fig 7. Current and voltage Waveforms

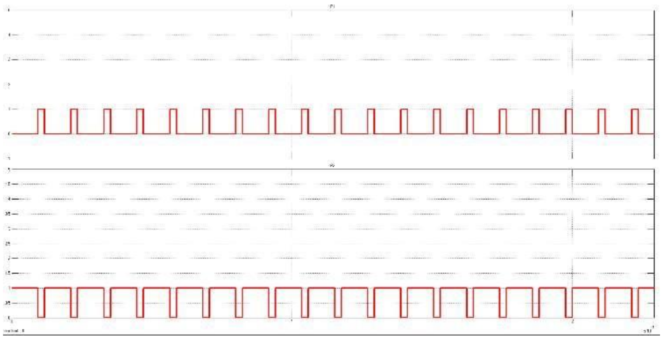

Fig 8. Waveforms of PWM Signals

COMPARISON

Table 1 : Comparison between PI and ANFISControl logic

SI. No	Parameter	PI	ANFIS
1	Overshoot	Increase	Decrease
2	Settling	More	Less
3	Transient	Present	Not Present
4	Stability	Worse	Good
5	Efficiency	89.3 %	96.8 %

FUTURE WORK

- By adding battery to this simulation circuit we can able to calculate the SoC and it will help us to give the required amount of currentand voltage.
- Smart EV Chargers can be adopted to this circuit with the help of Artificial Intelligence.

CONCLUSION

Compared to regular chargers, Fast EV chargers havethe potential to drastically shorten the amount of timeit takes to charge an electric car. Fast charging can, however, have certain downsides, such as greaterprices, increased battery stress, and possible grid limits.It is significant to remember that in addition tothe capabilities of the charging infrastructure, the rateof charging also relies on the battery's capacity, age, and temperature. Therefore, while determining whether to utilise a fast charger or a conventional charger, it is crucial to take these aspects into account.

REFERENCES

1. A. Srilatha, Dr. A.Pandian, Dr. P. Srinivasa Varma. “Review of Different Methods and Topologies for Fast Charging of Electric Vehicles”.In: IJRIAS | Volume V, Issue XI, November 2020 ISSN 2454-6194
2. Revath B C, Tanmayee R, Prashanth C Veeru,Nuthan B S, Vishwas K Singh, Gowtham B. A “Review on Electric Vehicle Charging Systems.”In: IRJET | Volume: 09 Issue: 04 | Apr 2022
3. Harish Ramakrishnan, Jayanth Rangaraju. “Power Topology Considerations for Electric VehicleCharging Stations.” In: Texas instrument |SLLA497 – SEPTEMBER 2020
4. Fatma Jarraya, Ahmad Khan, Adel Gastli, Lazhar Ben-Brahim, Lazhar Ben-Brahim, Ridha Hamila. “Design considerations, modelling, and control of dual-active full bridge for electric vehicles charging applications”. In: The Journal of Engineering | ISSN :2051-3305 (Online)
5. Md. Rezanul Haque, Saurav Das, MohammadRejwan Uddin, Md Saiful Islam Leon, Md. Abdur Razzak. “Performance evaluation of 1 kW asynchronous and synchronous buck converter-basedsolar-powered battery charging system for electric vehicles”. In: IEEE Region Symp. (TENSYMP), Jun. 2020, pp. 770–773.
6. M. R. Uddin, M. R. Uddin, K. F. I. Faruque, K.F. I. Faruque, P. Das, P. Das, K. M. Salim, and K. M.Salim, “An alternative PWM controlled high efficientsolution for 60 V electric vehicle charging system to replace typical iron core charger: Technicalperformance assessment and comparison of efficiency”. In: IEEE Region Symp. (TENSYMP), Jun. 2020, pp. 312–315.
7. K. F. I. Faruque, M. R. Uddin, M. I. I. Sakib, and K. M. Salim, ‘‘Multiple outputs converter design forBMS integrated Li-ion

battery charger appropriate forelectric vehicle,'' In: Int. Conf. Sci. Contemp. Technol. (ICSCT), Aug. 2021, pp. 1–5

8. S. Das, K. M. Salim, and D. Chowdhury, ''A novel variable width PWM switching based buckconverter to control power factor correctionphenomenon for an efficacious grid integrated electric vehicle battery charger,'' In: TENCON IEEE Region Conf., Nov. 2017, pp. 262–267
9. S.Das, K. M. Salim, D. Chowdhury, and M. M. Hasan, ''Inverse sinusoidal pulse width modulation switched electric vehicles' battery charger,'' In: Int.J. Electr. Comput. Eng. (IJECE), vol. 9, no. 5, p.3344, Oct. 2019.
10. J. Walter, R. W. De Doncker, "High-powergalvanically isolated DC/DC converter topology forfuture automobiles". In: IEEE 34th Annual Power Electronics Specialists Conference, vol. 1, pp. 27-32, June 2003.
11. MD. REZANUL HAQUE, K. M. A. SALAM ,MD. ABDUR RAZZAK. "A Modified PI-ControllerBased High Current Density DC–DC Converter for EV Charging Applications". In: IEEE ACCESS January 2023 VOLUME 11
12. J. Walter, R. W. De Doncker, "High-powergalvanically isolated DC/DC converter topology forfuture automobiles", In: IEEE 34th Annual Power Electronics Specialists Conference, vol. 1, pp. 27-32, June 2003.
13. Hari Om Singh ,S.K Tripathi, "Constant CurrentAdaptive Neuro Fuzzy Inference System Controller for Grid Connected Electric Vehicle Charging". In:IJRTI | Volume 7, Issue 7 | ISSN: 2456-3315.
14. Tufan Doğruer, Nusret Tan, "Design of PI Controller using Optimization Method in Fractional Order Control Systems" . In : Article in IFAC-Papers Online · January 2018.