ISSN: 2545-4523 (Online)

Electric Vehicle using a Bidirectional DC-DC Converter and an ANFIS Controller

Himanshu Dave

M.Tech Scholar, Bhagwant University Ajmer, INDIA

Abstract:

Despite the fact that hybrid electric cars offer many of the same benefits as hybrid automobiles, the primary difference is that the vehicles use an electric motor powered by an energy storage system that draws its energy from a secondary energy source such as batteries or a power grid to supplement the primary energy supply. The electric motor may also function as a generator, turning regenerative braking energy into electricity that is stored in the vehicle's energy storage unit, if one is available. It is common practise to incorporate a hybrid control method in an energy conservation analysis of a vehicle, which distributes the load across different operating modes, such as driving the vehicle. It is the purpose of this thesis to examine the introduction of an electric vehicle (EV) framework and the applications of this framework in combination with a hybrid energy storage system. This study presents a contemporary hybrid energy storage system for electric cars, which will enable for long-distance endurance and cost minimization while also allowing for cost reduction. Based on the state of charge of the supercapacitor, this thesis proposes an optimal control method for a hybrid energy storage device constructed on a Lithium-ion battery capacity dynamic constraint rule-based control based on the capacity of the Li-ion battery. The use of an ANFIS controller results in better outputs with less distortion for hybrid energy storage systems.

Keywords- Electric Vehicle, DC-DC, ANFIS

Introduction

The country's petroleum reserves do not have adequate reserves to satisfy the country's requirements. The price of crude oil and natural gas imported from other countries fluctuates, and this has a significant impact on the price of crude oil and natural gas. The United States and China are both ahead of India when it comes to total oil imports, despite the fact that India has slid to third position in the globe. On the basis of current estimates, India imports crude oil for 82.8 percent of the total petroleum basket, with natural gas imports accounting for 45.3 percent of the whole basket. It has been made a concerted effort to minimise the use of petroleum products in order to address the issue of air pollution, which has been compounded by the direct correlation between petroleum product consumption and air pollution. [3] Aside from that, because of the massive amount of crude oil imported, it places a tremendous economic burden on the people of India who live there. In order to reach these goals, we would need to increase our use of green renewable energies and nuclear energy while concurrently decreasing our dependence on fossil fuels, as previously indicated. In terms of petroleum products, it is projected that motorised vehicles account for more than half of total petroleum product use. As a result, the use of these automobiles contributes to considerable air pollution, which has a negative impact on our natural environment. India's high dependence on petroleum products in the transportation industry is a key contributing factor to this situation. A direct outcome of this is that new innovations in the field of transportation such as battery-powered Plug-in Electric Vehicles (PEVs) and Plug-in Hybrid Electric Vehicles (PHEVs) are gaining ground in the battle against greenhouse gas emissions and air pollution. Plug-in hybrid cars are electric vehicles that are recharged by utilising an external energy source, such as the electrical grid, to fuel their batteries. Plug-in hybrid vehicles are also known as plug-in electric vehicles (PEV). [5]

Many causes have contributed to the recent electrification of transportation, including the need for more electricity, the need for greater economic development, and a range of other considerations. Additionally, for a period of time, the railroads were fortunate in that they were able to operate a great variety of various types of electric locomotives. 6 Trains are scheduled to proceed on a preset route; they are travelling from point A to point B. Receiving electric power from a conductor rail is

ISSN: 2545-4523 (Online)

made much more easy with the aid of pantograph slider slides, which may be found here. The definition's scope has been expanded. As a result of the wide variety of utility alternatives (UTOPIA) that they provide, it is more difficult for electric vehicles (EVs) to acquire power in a comparable fashion. An electric car battery pack (usually of high power and large capacity) is also used as an energy storage device, allowing the vehicle to travel a reasonable distance between charging sessions. [7] Up until now, electric cars (EVs) have remained out of reach for the vast majority of purchasers, despite a slew of government incentives. Currently, government incentives and tax credits are vitally important in order to increase the market share of electric cars in the short term. [8] Make exaggerated claims Obtaining enough storage capacity for electric vehicle electricity, which is mostly provided by a battery, is the most challenging problem an electric vehicle must solve. Batteries, on the other hand, have become prohibitively costly as a result of their short life cycle, high cost, and poor capacity for storing energy. There are numerous requirements that must be met when developing a battery for an electric vehicle, which makes it very challenging. These features include a large energy volume, a high power density, an inexpensive cost, a long cycle life with great safety, and durability. Most people believe that lithium-ion batteries are the most cost-effective alternative for electric car batteries [10], and this is supported by the majority of experts. A complete pack of lithium-ion batteries in electric vehicles has an energy capacity of 90-100 Wh/kg, whereas the lithium-ion battery currently on the market has an energy capacity of only 90-100 Wh/kg [11], despite having an energy capacity of 90-100 Wh/kg for a complete pack of lithium-ion batteries. 1 With an estimated energy density of just 300 Wh/kg, it is much lower than that of gasoline, which has an energy density of over 12000 watt hours per kilogramme of weight. It takes a significant number of powerful and expensive batteries to match the 300-mile range of an internal combustion engine (ICE) vehicle. A pure electric vehicle (EV) can only go so far on a single set of batteries. According to the most recent available statistics, the average cost of a lithium-ion battery is presently approximately $500 per kilowatt-hour on average (numbers) It is estimated that owning a battery electric vehicle saves owners an extra $1,000 each year in terms of both the money necessary to purchase and maintain a gasoline-powered vehicle, according to the National Highway Traffic Safety Administration. [12]

Literature Review

Beyond the fact that electric vehicle batteries must be recharged on a regular basis, they must also be recharged over a lengthy period of time, making driving an EV costly for certain drivers. Depending on the power output of the associated charger, it may take anywhere from one to several hours to fully charge a single battery. Given that recharging a battery takes many times longer than refuelling a car with gasoline, it is advised that you charge several batteries in parallel. EVs will no longer be able to prepare themselves automatically if the battery has been entirely exhausted, according to the manufacturer. In the event that a company seeks to circumvent this, the company will ensure that the customer has access to an outlet and a charging cable at the moment of purchase. to see a rise in the number (numbers) Another issue that occurs as a consequence of the inability to connect is the inability to communicate. It is made more difficult by the fact that people are running out of battery power as a consequence of not plugging in. It is possible to get entangled in the wires that are laid out on the floor, which might result in an accident. Household members as well as the structure of the building may be at risk if aged wires, which are particularly prone to snapping in cold climates, are exposed. In addition, in order to turn on the power, people must struggle with bad weather conditions such as wind, rain, ice, or snow, among other things, in order to do so. As a result, there is a considerable increase in the likelihood of getting an electric shock. In greater detail, they are interested in wireless power transfer (WPT) technology since it reduces the hassles associated with charging their electric vehicles (EVs) [7] as EV owners. According to the experts, wireless charging was just as simple as transferring power from one electric vehicle to another via a wireless network. It is possible to use a WPT in a fixed location, requiring drivers to do nothing more than park and leave the vehicle. Using a dynamic WPT system, such as that found in an electric vehicle (EV), a vehicle may continue to operate while in motion, eliminating the need for the vehicle to stop. Aside from that, whereas electric vehicles equipped with wireless charging may see a drop in battery capacity of up to 20%, vehicles equipped with conductive charging do not see a reduction in battery capacity. Although it is vital to consider vehicle energy conservation as early in the component sizing process as feasible, this must be done as soon as possible since the energy storage unit has an impact on the electrical drive's ability to provide energy and control. It is clear that these choices make a major impact when it comes to automobile reliability. Additionally, their initial and continuing costs might have an impact on their capacity to generate a profitable business.

However, because to the enormous number of energy storage components available on the market, this article will only cover batteries and ultra-capacitors in this part due to the length of time it will take to cover them all. Battery storage capacity is substantial; yet, ultra-capacitors offer a high power density while requiring little storage space. In this case [1, it is an illustration of how a hybrid device may benefit from the advantages of both technologies].

Depending on the underlying principles of operation, an energy-based powertrain, such as a hybrid, that incorporates several sources of energy may be set in either the series or the parallel mode. A series configuration is used when the electric motor is solely responsible for driving the wheels; a parallel design is used when the wheels are powered by either the electric motor, the internal combustion engine, or a combination of both. Currently, the great majority of automobiles on the road are electric cars that work in parallel rather than series configurations. In a series system, since the electric motor is responsible for all control requirements, it must be adequately sized for the vehicle's maximum output. Because the electric motor only contributes to a percentage of the overall power required by the vehicle while both engines are functioning together, a smaller engine may be used in conjunction with the electric motor. The series configuration, although allowing the engine to operate at its optimal speed at all times, is generally associated with an expensive energy conversion method, in which mechanical energy from the engine is transformed to electrical energy that may be stored in a battery.

It is more difficult to run and maintain a non-electric vehicle due to the lack of onboard energy storage capacity. When it comes to hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEV), extended range electric vehicles (EREVs), fuel cell vehicles (FCVs), and electric vehicles, it has a substantial influence on the overall performance of the vehicle (EV). A significant amount of energy must be stored by the ESS in order to provide an acceptable pure electric range, provide enough peak power to satisfy vehicle performance requirements across a variety of driving cycles, utilise electricity more efficiently through regenerative braking, and have a long service life and low total cost of ownership, among other things. For the time being, pure battery-based ESS (such as power batteries) is unable to achieve any of these requirements due to a variety of trade-offs. When looking for ways to improve the overall performance of an ESS, researchers have looked into combining two (or more) energy sources in order to maximise the specific properties of each. This has resulted in the development of hybrid energy storage systems, which are a combination of two or more energy sources (HESS). In order to cope with this circumstance, the hybridization of high-energy batteries and ultracapacitors with complementary properties has been a popular approach in recent years, according to industry experts. According to the findings of this study when a variety of variables such as system power, efficiency, cost, practicality, and temperature requirements are taken into consideration, a HESS offers a considerable benefit as well as overall superiority. We go through the dormant, semi-active, and fully active variants of the battery-ultracapacitor HESS system in great depth: the dormant, semi-active, and fully active versions are all discussed in great detail. Following that, the efficacy of a number of HESS control systems that have been employed in the past, including rule-based or reference curve-based control, fuzzy logic control, and closed-loop control, is evaluated. During the presentation, a novel control method based on sparse coding and signal isolation was introduced, and at the end of the presentation, the new control technique was shown.

Recent years have seen an increase in the reliance of automobiles on high-capacity energy-storage devices. Batteries are the most common and potentially useful energy storage component in hybrid and electric vehicles (HEVs). They provide the significant energy output required for EV range extension while remaining relatively affordable. Although it should be emphasised that no one element (such as a battery) is capable of giving all of the necessary characteristics (such as lower power density) on its own, a combination of elements may achieve these results. The weight of the battery pack is reduced when the size of the battery pack is increased, but the cost of the battery pack increases as the size of the battery pack is increased. "Hybrid Energy Storage" is a term that refers to a system that combines a modest battery with low energy consumption (average power) with a supercapacitor with exceptionally high energy consumption (peak power) when travelling downhill or when saving energy through acceleration and regenerative braking to reduce energy consumption. Two major components of the HESS, one of which is a supercapacitor with high power density (a powerful energy source) and the other which is a battery with high energy density (an effective energy storage), work in concert to benefit the device's interests and those of its customers [1-5] by leveraging their complementary strengths.

The reality that there are so many different kinds of energy storage components available on the market, however, necessitates the fact that this article will only address batteries and ultra-capacitors in this part. When compared to ultra-capacitors, which have the ability to store significant amounts of power, batteries have the ability to store significant amounts of energy. For the sake of summarising, a hybrid system [1] is one that includes the advantages of both technologies in this particular context.

Implementation

In figure 1, model implementation for dual battery storage for electric vehicle is shown on MATLAB Simulink.

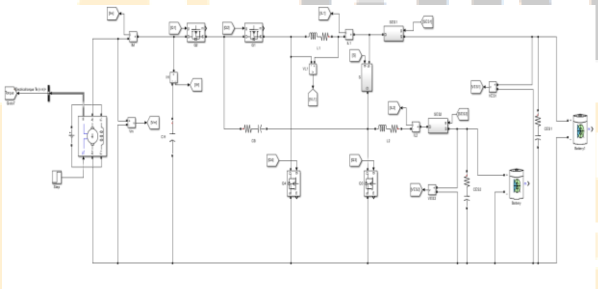

Figure 1: Model Implemented for Electric Vehicle

In figure 2, ANFIS controller and SPWM controller is shown.

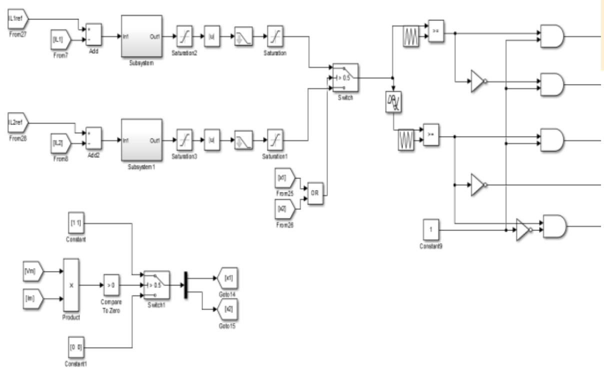

Figure 2: Proposed Control System for ANFIS and SPWM

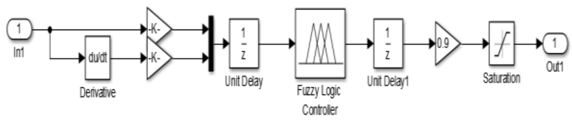

Figure 3: ANFIS part

In figure 3, the error and change in error input is given to fuzzy logic controller for ANFIS rule application.

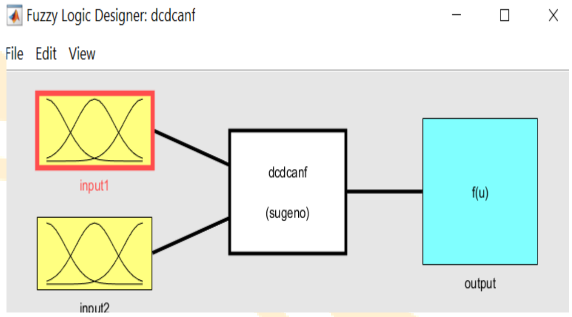

Figure 4: Fuzzy Rule input and Output

In figure 4, fuzzy rule input and outputs are shown.

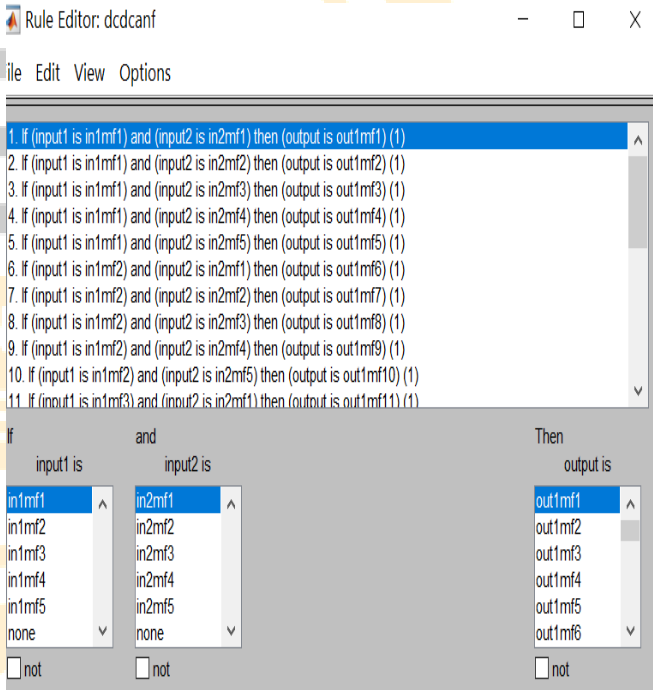

Figure 5: Rules Screen

In figure 5, rules for Sugeno type are shown.

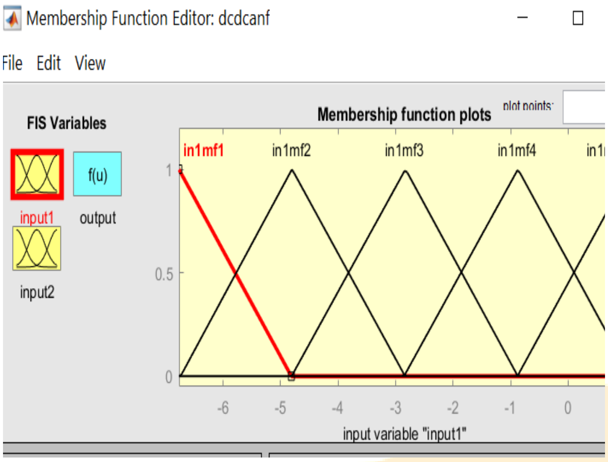

Figure 6: Input Membership Functions

In figure 6, 5 membership functions for input are shown.

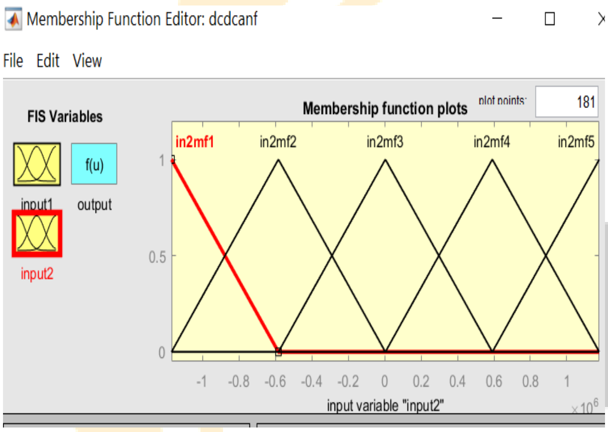

Figure 7: output membership function for BDC

In figure 7, 5 membership functions for output are shown.

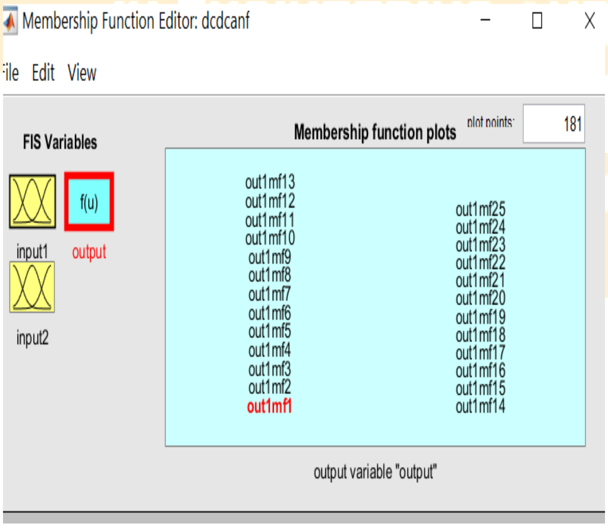

Figure 8: Membership function for Output BDC

In figure 8, membership function for output BDC with HESS are shown.

In figure 9, the final ANFIS Structure for bidirectional hybrid storage for electric vehicle is shown. This is proven to improve the distortions found earlier in PI controller.

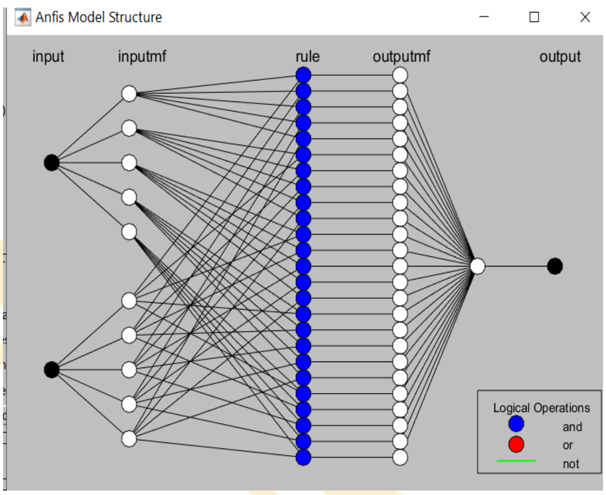

Figure 9: ANFIS Structure for Hybrid Electric Vehicle Controller

Results

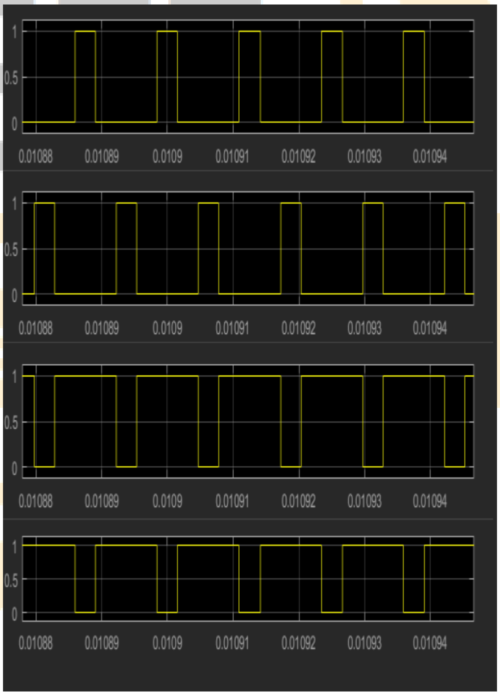

Figure 10: Switching of gate pulses

In figure 10, switching of gate pulses is shown.

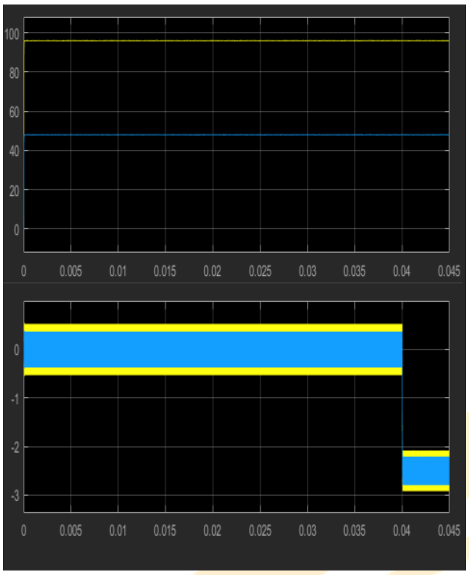

Figure 11: Inductor current and battery potential

In figure 11, battery potential and inductor current with low fluctuations is shown. It gives better in case of ANFIS controller.

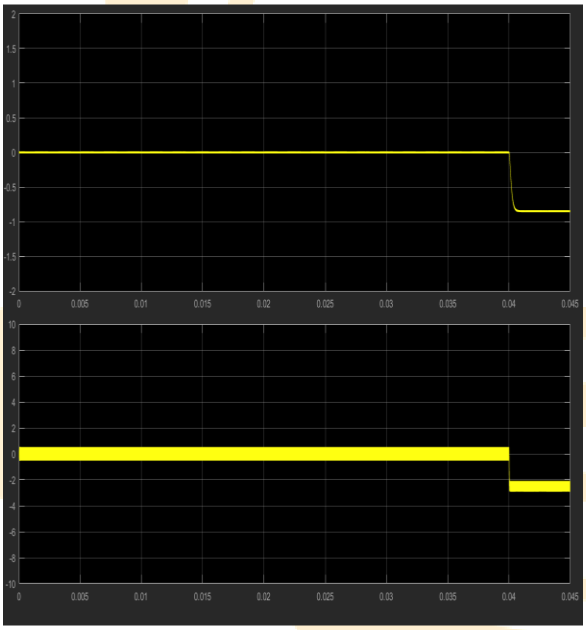

Figure 12: Inductor currents

Above image figure 12, shows the fluctuations are less and smoother transitions in case of mode changes.

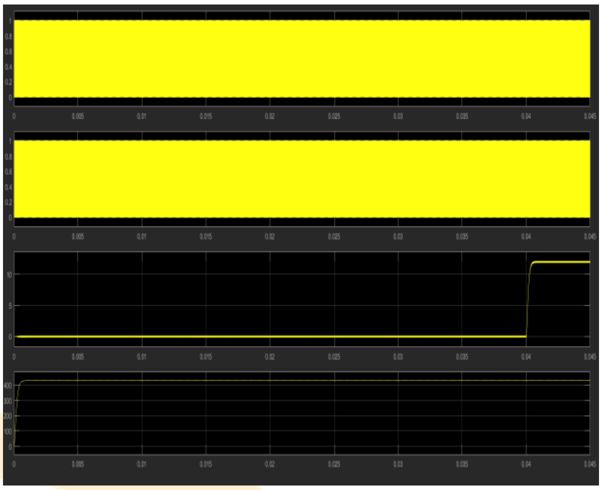

Figure 13: Output waveforms

In figure 13, the output are shown which shows better transitions and lesser distortions as compared to PI controller outputs.

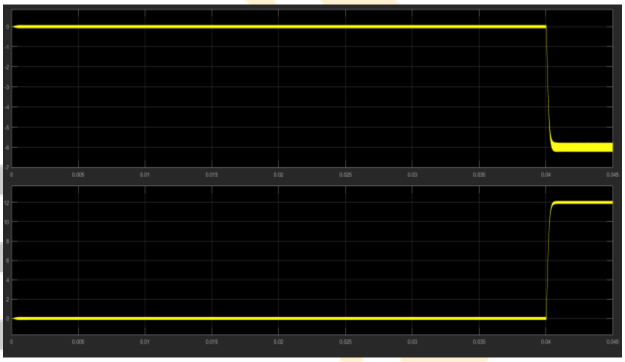

Figure 14: Final Inductor Currents

In figure 14, the output transitions for inductor current are shown which give less distortions and smoother waveforms.

Conclusion

Electric autos have piqued the public's curiosity due to its promise to significantly cut energy usage as well as emissions of hazardous pollutants into the environment. In spite of the fact that governments and car manufacturers continue to agree on new electric vehicle market goals, the cost of producing electric vehicles continues to decline, making them more competitive with internal combustion vehicles. Advances in lithium-ion battery technology have played a critical role in the increasing popularity of electric vehicles, and a further shift to electric driving will need a significant increase in battery capacity. In the early phases of research, efforts are being made to get a better understanding of the precise environmental consequences of electric cars. The impacts of battery output on the total pollution created by electric vehicles are particularly complex to understand. Several recent studies have looked at the greenhouse gas emissions associated with battery manufacture, and the results have shown a wide variety of conclusions and consequences for battery manufacturing. For this reason, the energy storage device (ESS) is referred to as the "brains" of electric vehicles due to the fact that it is responsible for the performance, strength, and driving range of these vehicles. Growing demand for new electric vehicles often results in the need for a high energy density, as well as a high peak capacity, which necessitates the use of the ESS for its operation. Batteries and supercapacitors, which are capable of storing large amounts of energy and power, are often used as the energy storage system (ESS) in industrial applications these days, particularly in the automotive industry. An alternating current bidirectional DC-DC converter is created for use in hybrid electric autos, and dual battery energy sources are used in this thesis. The lifetime of a system with a PI controller is lowered as a result of the changes generated by the employment of a PI controller. In the proposed research, the smoother transitions and less distortion are achieved by combining an ANFIS controller with SPWM. This results in a longer lifetime and improved accuracy for such storage systems.

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