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COMPARATIVE ANALYSIS BETWEEN FUZZY AND FUZZY-PID OF BIDIRECTIONAL DC-DC DRIVER FOR ELECTRIC VEHICLES

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ABSTRACT

Battery fed electric vehicles is required to function in three different modes namely, acceleration mode, normal mode and braking mode. During acceleration and normal nodes the power flow is from battery to motor where as during braking or regenerative mode the kinetic energy of the motor is converted into electrical energy and fed back to battery. The DC-DC converter is required to perform mainly two functions: first to match the battery voltage to the motor rated voltage and second to control the ottery power flow under steady-state and transient conditions, so that the drive ce is as per the requiremes the present work closed loop operation of performance bl-directional dc-dc converter fending In converter feeding a motor and its regenerative braking has been demonstrated. The characteristics of battery operated its energy recovery due to electric vehicle under different drive condition are also presented. The bi-directional dc-dc converter is s controlled with fuzzy logic controller in both modes. The proposed converter and controller are designed to meet charge control and motor drive requirements of an all-electric vehicle. comparative analysis between fuzzy and FUZZY-PID of bi-directional dc-dc driver for electric vehicles. Total circuit configuration is simulated in MATLAB simulation.

Introduction

Transportation sector occupies a fundamental place in the world. Fossil fuels used in conventional vehicles technology emit greenhouse gases such as carbon dioxide, carbon monoxide and methane. The excessive consumption of these gases causes air pollution, climate change and global warming. In order to reduce these effects, there is a tendency to electric vehicle (EV) technology. The EV has much lower fuel cost according to fossil fueled car since they are mainly composed of battery system, power electronic circuits and electric machine. The battery system in an EV is the most crucial component in charge control time and determining distance . The electric machines of an EV are operated in both motor and generator modes due to regenerative breaking feature that enables electric machine to be operated in generator mode which is impossible in conventional internal combustion engine (ICE) vehicles. Therefore, electric machine charges the battery by operating in generator mode during the regenerative braking and it ensures recharging the batteries . EV are classified into two types as hybrid EVs (HEVs) and all-electric vehicles. The HEV technology is used in conjunction conventional vehicle technology. The main system in HEV technology includes fuel tank and ICE such as diesel or gasoline engine, and auxiliary system which is comprised by electric machine, power electronic circuits and battery. HEVs are classified as parallel and series hybrid vehicles that the parallel HEV consists ICE and electrical machine together. As the parallel electric vehicles operates at electric mode during the acceleration of electric machine, the motor operation is supplied from battery

The designed EV motor driver is comprised by four sections such as battery, bi-directional dc-dc converter, FLC and dc machine as shown In this study, the starting voltage of battery is set to 378 V while the operating voltage of dc machine used in traction system is 500 V dc. The battery voltage is increased up to 500 V with bi-directional dc-dc converter in generator mode. The battery

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is discharged when dc machine is started acceleration. The motor mode simulation with various torque values are performed to observe battery parameters such as state of charge (SoC), current, voltage and voltage of the dc machine. The voltage of the dc machine is decreased to 500 V with bidirectional dc-dc converter which is controlled with FLC. The battery is charged during the generator mode operation of dc machine. The FLC determines duty cycle of S1 and S2 to ensure charge and discharge of battery. The dc machine is comprised by brushes, armature core and windings, commutator, field core and windings. Armature circuit is comprised by series structure with inductor, resistance and counter-electromotive source. Similarly, battery parameters such as SoC, current, voltage and voltage of the dc machine are observed in the generator mode simulation regarding to various torque values applied to dc machine.

The electrical energy is converted to mechanical energy or vice versa by dc machine that operates regarding to electromechanical energy conversion theory . If a conductor is mo1ved within the magnetic field, the voltage is induced on it which is known as generator operating mode. If alternating current passes through the conductor, magnetic field is created around it which explains the motor mode operation. When the dc machine is started acceleration, the resultant positive torque is achieved. On the other hand, negative torque is generated at the dc machine when it is operated in generator mode

FLC is comprised by fuzzification, rule base, interface mechanism, defuzzification. Fuzzification is used to convert digital signals received through the system into linguistic variable. Rule base is comprised by the conditions to set for controlling the system at desired location. Interface mechanism makes inferences according to the rules of system by establishing a relationship between inputs. Defuzzification is used to convert linguistic variable received through the system into digital signals

The European new vehicle CO2 regulation (with a mandatory target value of 95 grams of CO2 per kilometer by 2021 for passenger cars) is currently in the process of being extended to 2025. In this context, one of the key questions is at what point a significant uptake of the electric vehicle market is to be expected. In order to help inform this debate about how electric vehicle technology could fit in a lower-carbon 2020–2030 new vehicle fleet in Europe, this paper focuses on collecting, analyzing, and aggregating the available research literature on the underlying technology costs and carbon emissions. In terms of technologies, this paper concentrates on the three electric propulsion systems: battery electric vehicles (BEVs), plug-in hybrid electric vehicles (PHEVs), and hydrogen fuel cell electric vehicles (HFCEVs). The collected cost data is used to estimate the technology cost for automotive lithium-ion (Li-ion) batteries and fuel cells. The cost of battery packs for BEVs declined to an estimated €250 per kWh for industry leaders in 2015. Further cost reductions down to as low as €130–€180 per kWh are anticipated in the 2020–25 time frame. The costs of fuel cell systems are also expected to decrease considerably, but cost estimates are highly uncertain. Furthermore, the application of fuel cells and batteries in HFCEVs, BEVs, and PHEVs is approximated using a bottom-up cost approach. Overall, the different power train costs largely depend on battery and fuel cell costs. This paper concludes that the costs of all power trains will decrease significantly between 2015 and 2030. As shown, power trains for PHEVs will achieve about a 50% cost reduction, compared with approximate cost reductions of 60% for BEVs and 70% for HFCEVs. Costs for hydrogen and electricity chargers are estimated separately. Greenhouse gas (GHG) emissions and energy demand for electric and conventional vehicles are presented on a well-to-wheel (WTW) basis, capturing all direct and indirect emissions of fuel and electricity production and vehicle operation. The results are based on former analyses, and are updated and refined with real-world fuel consumption levels. Real-world fuel consumption is commonly about 20%–40% higher than official typeapproval measurements. Finally, WTW estimates for electric and conventional vehicles are put in the context of the 2021 CO2 standard for European passenger vehicles. It is found that carbon emissions of BEVs using European grid-mix electricity are about half of average European vehicle emissions, whereas HFCEVs and PHEVs have a lower emissions reduction potential. In the 2020 context, electric vehicle WTW emissions are expected to continue offering greater carbon benefits due to more efficient power trains and increasing low-carbon electric power. A lower-carbon grid and higher power train efficiency by 2020 could cut average electric vehicle emissions by one-third again. However, the expected cost reductions and potential CO2 emission cuts will not be achieved without targeted policy intervention. More stringent CO2 standards, and fiscal and non-fiscal incentives for electric vehicles, can help the electric vehicle market to grow and costs to fall. Also, efforts need to be combined with activities to decarbonize the grid, or emission reductions will not be as great as they could be. Although the analysis is focused on the European context, similar dynamics with electric vehicle technology, policy, and market development are prevalent across major markets in North America and Asia.

The first EVs were introduced as early as 1838—or 52 years before internal combustion engine vehicles (ICEVs) entered the market. Despite recent growing interest, EVs have remained a relatively small market until today (IEA, 2015). However, the global share of EVs is expected to increase significantly, driven by substantial battery technology improvements and a variety of policies that are accelerating the development of the electric vehicle market. Overall, the market has grown from just hundreds of EV sales in 2010 to more than 500,000 sales worldwide in 2015 (EV Sales, 2016). The early development of markets for electric vehicles is seen predominantly in parts of China, Europe, and the United States, where electric vehicle support policies are helping promote the technology, while costs are still relatively high compared with conventional vehicles. Table 1 shows the global and regional estimated stock of BEV and PHEV passenger cars as of 2015, and electric vehicle supply equipment (EVSE) as of 2014. EVSE includes semipublic or public charging points or outlets, but not private charging points. Most of the electric vehicles on the road today are registered in the United States, with about half of those in the state of California. The United States also has the largest number of electric vehicle charging points. The Netherlands is the European country with the highest electric vehicle passenger car and charging-plug stock in terms of absolute sales. The following countries have achieved relatively high market sales shares of passenger electric vehicles, as a percentage of all 2014 passenger vehicle sales: Norway (13.7%), the Netherlands (3.9%), Sweden (1.5%) (Mock, 2015), and the United States (1.5%) (Lutsey, 2015b). Most other major automobile markets have EV sales shares at or below 1%.

Pure battery electric vehicles (BEVs) are also referred to as battery-only electric vehicles (BOEVs). BEVs have no engine and are propelled by electricity that comes from one or several onboard high-energy batteries. Modern models use a regenerative braking system to save energy. Examples include the Renault Zoe and the Nissan Leaf. The Zoe has a 22 kWh Li-ion battery, and an energy consumption of 14.6 kWh per 100 km, which yields a range of about 140 km to 210 km per battery charge on the New European Driving Cycle (NEDC). The 2015 Leaf comes with a 24 kWh battery (plus a 30 KWh option for the 2016 model), and an official consumption of 15 kWh per 100 km. 3.2. PHEVs Plug-in hybrid electric vehicles (PHEVs) allow electric driving on batteries (in charge-depleting mode), but also conventional combustionfueled driving (in charge-sustaining mode). Usually, they are equipped with an electric motor and a highenergy battery, which can be charged from the power grid. Modern PHEVs can be driven in electric mode over varying distances before the combustion engine is required. In electric-driving mode, the energy efficiency of the propulsion system is much higher, and is comparable to that of a BEV. Available models include the Chevrolet Volt in U.S. markets (which is the Opel Ampera in EU markets), and the Toyota Prius Plug-in Hybrid. The 2015 Opel Ampera uses a 16 kWh Li-ion battery and consumes 16.9 kWh per 100 km in electric mode on the NEDC. The 2015 Chevrolet Volt has a 16.5 kWh battery, and the 2016 model has an 18.4 kWh battery

PHEVs and BEVs use similar batteries, with Li-ion being the most common chemistry. There are two primary ways to extract the lithium used in batteries: mining spodumene and petalite ore using evaporation ponds on salt lakes. The majority of lithium is obtained from brine operation (USGS, 2015). The battery system is the key technology of electric vehicles and defines their range and performance characteristics. The battery works like a transducer by turning chemical energy into electrical energy. Li-ion is expected to be the dominant chemistry for BEVs and PHEVs for the foreseeable future, as most research is done in the field of Li-ion batteries. They provide relatively high power and energy for a given weight or size, and can significantly reduce costs compared with other battery concepts. Energy density of the battery pack is estimated to roughly double, up to about 300 Wh per kg, between 2007 and 2030 (Kromer & Heywood, 2007; Ricardo-AEA, 2015; NAS, 2013). Also, they have a relatively long life cycle and low selfdischarging losses. One of their few drawbacks is their sensitivity to overcharging, which is why they require a battery management system. Other automotive battery concepts include nickel-metal hydride (Ni-MH), sodium-nickel chloride (Na/NiCl2), and non-electrochemical alternatives such as supercapacitors, which allow fast charging but provide low energy density. As a result, batteries with higher energy and power densities are being developed, such as lithiumair (Li-air), lithium-metal or lithiumsulphur (Li-S), but these are far from commercialization (Cookson, 2015; Hacker, Harthan, Matthes & Zimmer, 2009). Li-air batteries may reach energy densities of up to 11,680 Wh per kg (Imanishi & Yamamoto, 2014), which approximates the energetic content of gasoline.

Problem Identification

This is the method where there is no scope to charge battery when vehicle in off condition. By using the fuzzy logic and bidirectional dc-dc converters when the time of vehicle in off condition and moving with speed that mechanical energy is converted into electrical energy.

The battery discharges when vehicle in start condition and bidirectional dc-dc converter act as a boost converter. The state of charge of a battery is decreases when vehicle in on condition and state of charge of a battery is increases while the vehicle in off condition and moving.

When the battery is discharged, the dc machine is operated in motor mode and bi-directional dc-dc converter is operated in boost mode. Variable positive torque values are applied to the dc machine and condition of the battery is observed. According to simulation result, the battery SoC is reduced from %88 to %87.337 and voltage of the dc machine is constant at 500 V. When the battery is charged, the dc machine is operated generator mode and bi-directional dc-dc converter is operated in buck mode. Variable negative torque values are applied to the dc machine and effect on the battery is observed. According to simulation result, the battery SoC is increased from %87.337 to %87.445. In all-electric vehicle, regenerative breaking is occurred in this state. Charge and discharge states of the battery are the most essential for distance to determining.

The objective of project is to charge the battery when dc machine acts as a generator. When the battery is discharged, the dc machine is operated in motor mode and bi-directional dc-dc converter is operated in boost mode. Variable positive torque values are applied to the dc machine and condition of the battery is observed. Charge and discharge states of the battery are the most essential for distance to determining.

Proposed Model

In recent years, the number and variety of applications of fuzzy logic have increased significantly. The applications range from consumer products such as cameras, camcorders, washing machines, and microwave ovens to industrial process control, medical instrumentation, decision-support systems, and portfolio selection.

Fuzzy logic has two different meanings. In a narrow sense, fuzzy logic is a logical system, which is an extension of multivalve logic. However, in a wider sense fuzzy logic (FL) is almost synonymous with the theory of fuzzy sets, a theory which relates to classes of objects with un-sharp boundaries in which membership is a matter of degree. In this perspective, fuzzy logic in its narrow sense is a branch of fl. Even in its more narrow definition, fuzzy logic differs both in concept and substance from traditional multivalve logical systems.

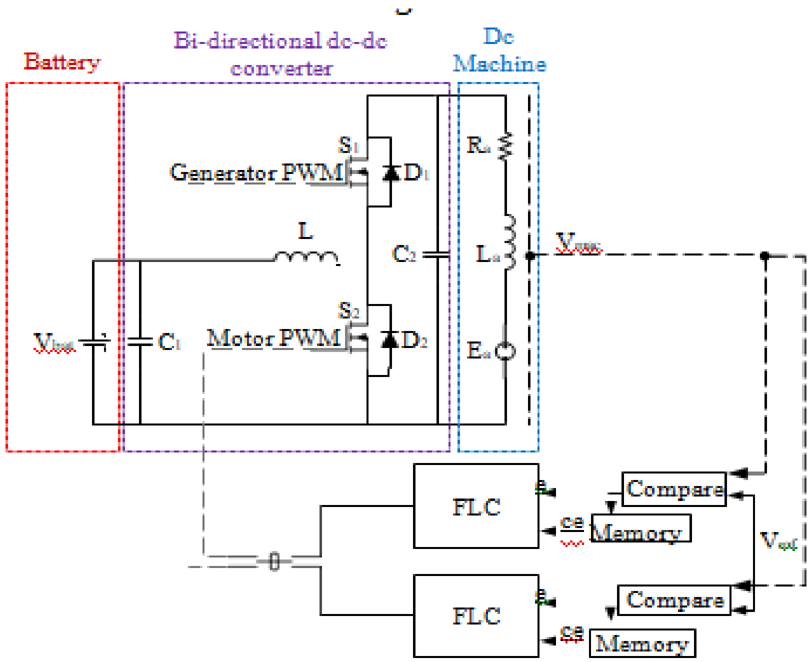

Fig. 1Circuit diagram of EV Machine Driver

The basic concept in FL, which plays a central role in most of its applications, is that of a fuzzy if-then rule or, simply, fuzzy rule. Although rule-based systems have a long history of use in Artificial Intelligence (AI), what is missing in such systems is a mechanism for dealing with fuzzy consequents and fuzzy antecedents. In fuzzy logic, this mechanism is provided by the calculus of fuzzy rules. The calculus of fuzzy rules serves as a basis for what might be called the Fuzzy Dependency and Command Language (FDCL). Although FDCL is not used explicitly in the toolbox, it is effectively one of its principal constituents. In most of the applications of fuzzy logic, a fuzzy logic solution is, in reality, a translation of a human solution into FDCL.

A trend that is growing in visibility relates to the use of fuzzy logic in combination with neuro computing and genetic algorithms. More generally, fuzzy logic, neuro-computing, and genetic algorithms may be viewed as the principal constituents of what might be called soft computing. Unlike the traditional, hard computing, soft computing accommodates the imprecision of the real world.

The battery voltage is stable at 1300 V while the voltage of dc machine is constant at 1350 V during first 25 seconds. Bi-directional dc-dc converter is operated in boost mode and dc machine operated in motor mode.

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The dc machine is operated during first 25 seconds in motor mode and last 25 seconds in generator mode.

Between 0 and 5 seconds: The starting torque value shown in Fig.6.3 which is implemented to the dc machine is set to 5 N.m and it is increased up to 15 Nm in fifth seconds. The current fluctuates between 26.7 A and 30.6 A is supplied by battery while battery SoC decreases from %88 to %87.965.

Between 5 and 10 seconds: The constant 15 N.m torque value is applied to dc machine during five seconds. The battery current is obtained to constant at 30.6 A and battery SoC reduces from %87.965 to %87.95.

Between 10 and 15 seconds: The torque value implemented to dc machine is enhanced to 20 N.m in the fifteenth second. The current of battery is observed between 30.6 A and 35 A. It i s lower than discharge current of battery. The battery SoC decreases from %87.95 to %87.942.

Between 15 and 20 seconds: The dc machine torque value is decreased down to 15 N.m in the twentieth second. The battery current is decreased from 35 to 26.25 A whereas battery SoC reduces from %87.942 to %87.935.

Between 20 and 25 seconds: The constant 10 N.m torque value is implemented to dc machine during five seconds. The battery current is observed as constant at 26.25 A and battery SoC reduces from %87.935 to %87.90.

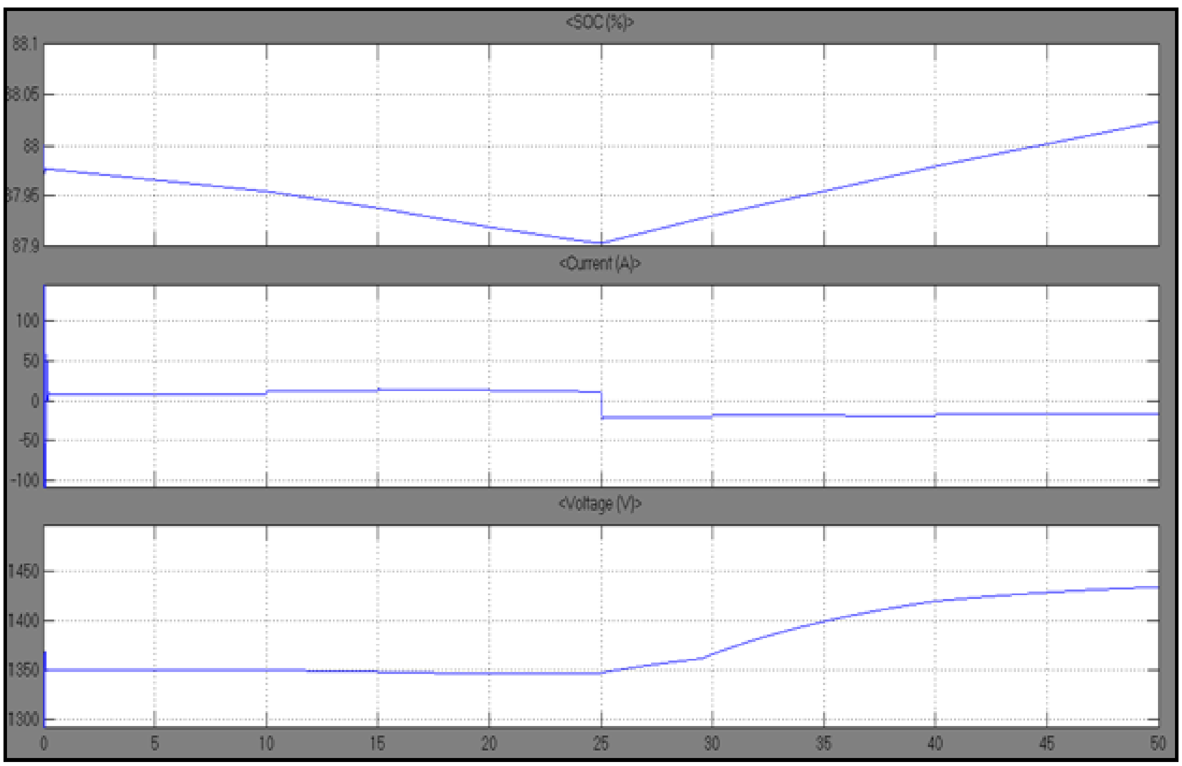

Fig.2 Proposed system Battery SOC, current, voltage

The figure 2 depicts the system battery SoC%, current and voltage which are indicating Performance of a battery.

The battery voltage is stable at 1330 V while the voltage of dc machine is constant at 1350V during first twenty five seconds. When torque value is positive torque, dc machine is operated in motor mode and according to torque value, it is acceleration. Bi-directional dc-dc converter is operated between 0 and 25 seconds in boost mode of bi-directional dc-dc converter. FLC generates duty ratio and it is compared with triangle waveform which has switch frequency and so switching pulse is generated for semiconductor switch. Voltage of dc machine is increased to desired value. As torque is increased, the dc machine current is increased up to discharged current of battery. On the other hand, as torque value is reduced, the current of battery is decreased.

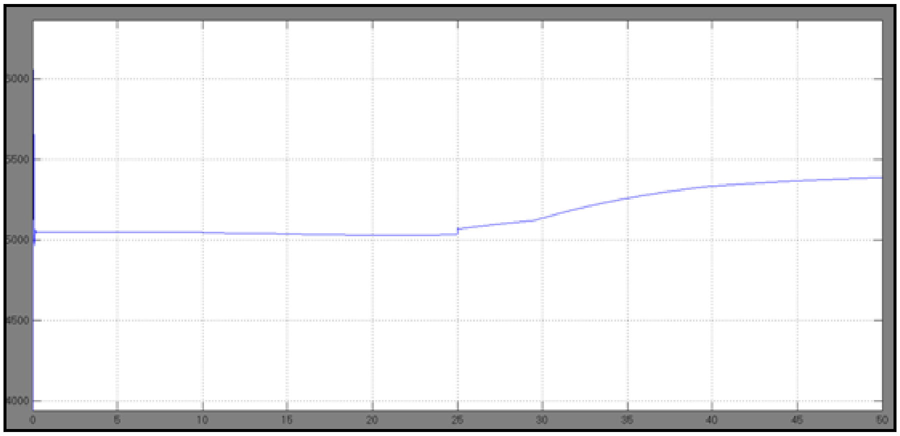

Fig.3 Proposed system Speed of the dc machine

On Fig. 3, you can see the speed of the dc machine, it explains the control of dc machine on different conditions.

Between 25 and 30 seconds: The torque value is decreased down to -70 N.m in the twenty fifth second and increased to -65 N.m in the thirtieth second. The battery voltage is increased from 1340 V to 1360 V. The battery current fluctuates between 0 A and -18.47 A and battery SoC increases from %87.90 to %87.936. The voltage of the dc machineis enhanced from 1350 to 1370 V.

Between 30 and 35 seconds: The torque value is implemented as constant -65 N.m. The voltage of batttery is acquired as constant at 1400 V while the current of battery is obtained as stable at -17.94 A. The SoC of battery increases from %87.936 to %87.951 and the voltage of dc machine is observed as constant at 1410.5 V.

Between 35 and 40 seconds: The torque value is enhanced to -60 N.m in the fortieth second. The battery voltage is decreased from 1400 V to 1395 V. While current of battery is changed between -17.94 A and -15.62 A, the SoC of battery increases from %87.951 to %87.97 and the voltage of the dc machine is decreased from1410.5 to 1400 V.

Between 40 and 45 seconds: The torque value is implemented as constant -60 N.m during five seconds. The battery voltage is acquired to constant at 1405 V while the battery current is observed as constant at -15.1 A. The battery SoC increases from %87.97 to %88. The voltage of the dc machine is constant at 1420 V.

Between 45 and 50 seconds: The torque value of dc machine is enhanced up to -55 N.m in the fiftieth second. The voltage of battery is decreased from 1405 V to 1402 V whereas the battery current is changed between -15.1 A and - 12.78 A. The battery SoC increases from %88 to %88.02 and also the voltage of the dc machine is decreased from 1420 to 1410 V.

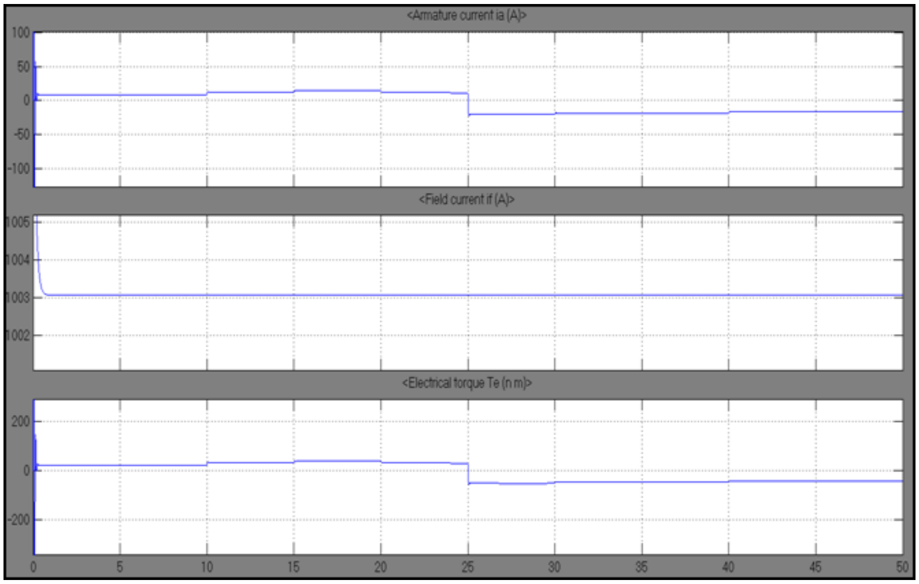

Fig.4 Proposed system Armature current, Field current, Electro magnetic torque

As illustrated in Fig. 4 when torque value is negative, the dc machine is operated as generator mode and the battery is supplied by dc machine. The bi-directional dc-dc converter is operated between 25 and 50 seconds in e buck mode of bi-directional dc-dc converter. FLC generates duty ratio and it is compared with triangle waveform that has switching frequency and switching pulse is generated for semiconductor switch. The voltage of dc machine is reduced to desired voltage value. The battery voltage and SoC are increased according to variable torque value. When torque value is increased as absolute value, the SoC, voltage and current of battery are increased. On the other hand, as absolute torque value is reduced, the SoC, voltage and current of battery are decreased.

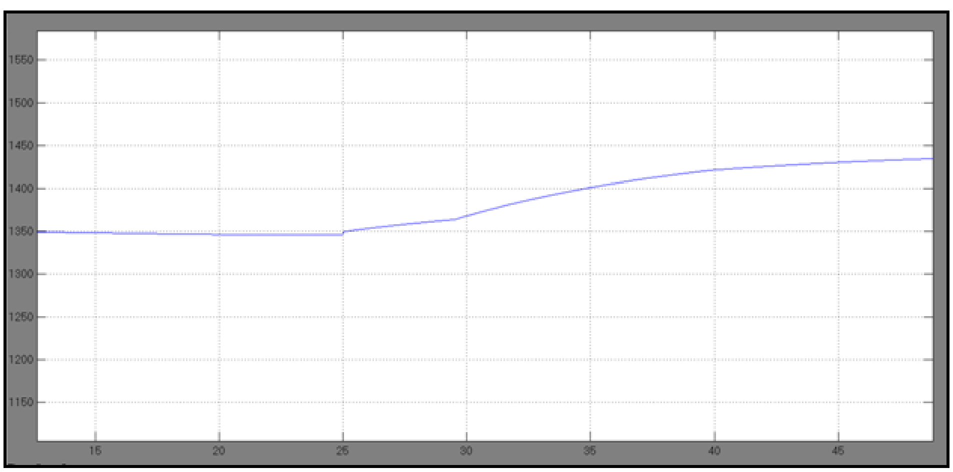

Fig.5 Proposed Dc machine across voltage

CONCLUSION

This project presents design and control bi-directional dcdc converter for all-electric vehicle. The bi-directional dc-dc converter is controlled with FLC according to rules. When the battery is discharged, the dc machine is operated in motor mode and bi-directional dc-dc converter is operated in boost mode. Variable positive torque values are applied to the dc machine and condition of the battery is observed. According to simulation result, the battery SoC is reduced from %88 to %87.9 and voltage of the dc machine is constant at 1400 V. When the battery is charged, the dc machine is operated generator mode and bi-directional dc-dc converter is operated in buck mode. Variable negative torque values are applied to the dc machine and effect on the battery is observed. According to simulation result, the battery SoC is increased from %87.9 to %87.984. In all-electric vehicle, regenerative breaking is occurred in this state. Charge and discharge states of the battery are the most essential for distance to determining.

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