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THE DESIGN AND CONTROL SYSTEM OF SMALL ELECTRIC VEHICLE (EV): A REVIEW

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ABSTRACT

In this study explain about the design and development of small electric vehicles (EV) using power inverter. Fully electric vehicles with multiple drivetrains allow a significant variation of the steady-state and transient cornering responses through the individual control of the electric motor drives. As a consequence, alternative driving modes can be created that provide the driver the option to select the preferred dynamic vehicle behavior. This article presents a torque-vectoring control structure based on the combination of feed forward and feedback contributions for the continuous control of vehicle yaw rate. The controller is specifically developed to be easily implementable on real-world vehicles. In this paper, DC power will convert to AC power for AC motor drive of the electric vehicles. The design and accessories of this electric vehicle are including battery, controller and motor. In this paper also need to identify the advantages of the electric vehicles in terms of environment, energy and cost. Moreover, this study also focused to compare the performance of electric vehicle with DC powered, AC powered and engine.

Keywords: small electric vehicle, transmission system, power converter, control system.

INTRODUCTION

Research and innovation into electric and alternatively fuelled vehicles which includes pure Battery Electric Vehicles (BEV), Hybrid Electric Vehicles (HEV), and Plug-in Hybrid Electric Vehicles (PHEV) is continuing at pace as they are viewed as a sustainable way to reduce both the dependency on fossil fuels and carbon output. The number of electric miles can be increased by storing energy in batteries located within the vehicle in order to power the drivetrain. When this store is depleted the batteries need to be recharged. This is typically done by plugging in a wired cabled system which is connected to the electricity grid. An emerging technology to support green driving is inductive charging.

Inductive, or wireless, charging uses an electromagnetic field to transfer energy between two objects, and offers an attractive alternative to the users having to physically plug in their EV to charge the batteries. To initiate charging the user simply parks over a transmitting inductive coil which is embedded in the ground, and the receiving coil located on the vehicle automatically detects this and charging begins. Whilst inductive charging technology is market ready, the efficiency of transfer of electrical energy is highly reliant on accurate alignment of the coils involved. He and colleagues envision that high-power, high-efficiency wireless power transfer technologies will be mature in the ‘near-future’ [1].

As the number of EVs on the road increases, their grid impact is observed more widely, e.g., altered grid load profiles, increased peak power, and increased voltage magnitude deviations [2]. The residential low voltage (LV) grid impact may be challenging, due to the simultaneity between the residential peak power consumption and the plugging in of EVs when arriving at home, which starts the charging process for uncoordinated charging. Therefore, an extensive amount of research is conducted on coordinated charging strategies [3].

The rising number of electric vehicles (EV) will eventually lead to a comparable number of EV batteries reaching their end of the life. Efforts are therefore being made to develop technologies and processes for recycling, remanufacturing and reusing EV batteries. Advancements in lead-acid battery technologies have increased the practicality and attractiveness of electrically-driven vehicles (EV), leading to an increase in their development and production, as well as that of lead-acid battery.

In this study, lead-acid battery and electronic vehicle design has been proposed. The lead-acid battery was chosen because it has some special characteristic due it’s rechargeable such as durable operating system and reversible chemical reaction than other types of battery. In this study has also introduced the control system of electric vehicle and power transfer system.

SYSTEM CONFIGURATION AND LEAD-ACID BATTERY SYSTEM

AC power system

There are two main types of AC motors, depending on the type of rotor used. The first type is the induction motor, which runs slightly slower than the supply frequency. The magnetic field on the rotor of this

VOL. 11, NO. 6, MARCH 2016 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

motor is created by an induced current. The second type is the synchronous motor, which does not rely on induction and as a result, can rotate exactly at the supply frequency or a sub-multiple of the supply frequency. The magnetic field on the rotor is either generated by current delivered through slip rings or by a permanent magnet. Induction motors and synchronous motors have been used for many years in constant-speed industrial applications but have only become possible for electric vehicles use with the advent of high-power, high-efficiency, variable-frequency inverters.

Structure of lead-acid batteries

In this research need to choose lead-acid battery because it is rechargeable battery and more durable in operating system to supply electric to the controller. A lead-acid battery is an electrical storage device that uses a reversible chemical reaction to store energy. It uses a combination of lead plates or grids and an electrolyte consisting of a diluted sulphuric acid to convert electrical energy into potential chemical energy and back again. Battery electric vehicles store electrical energy from the grid electrochemically to provide the vehicle with its only source of energy. The weaknesses of electrochemical energy storage is relatively to conventional petroleum-based fuels includes low specific energy, low energy density and recharging rate [4].

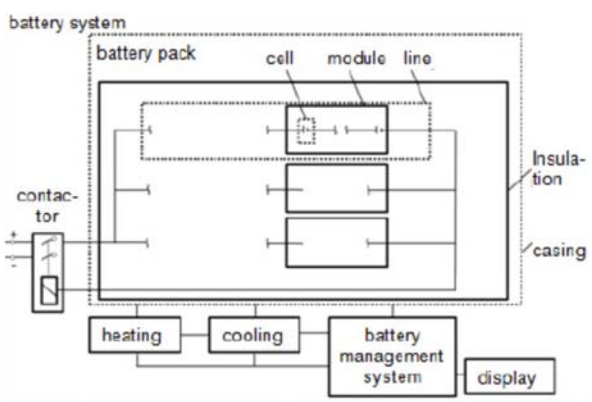

Figure-1. General design of lead-acid battery system [5].

The vehicle is powered by an electric engine using the energy from the battery system, as well as powered by an internal engine. The battery cells are put together to modules and connected with conductors. These stacks are then connected to lines or directly to battery packs. Together with the components for heating or cooling, the battery management system and the display battery pack are placed in an insulated casing and forms together with the power electronics, the battery system. The schematic design of a battery system can also be seen in Figure-1.

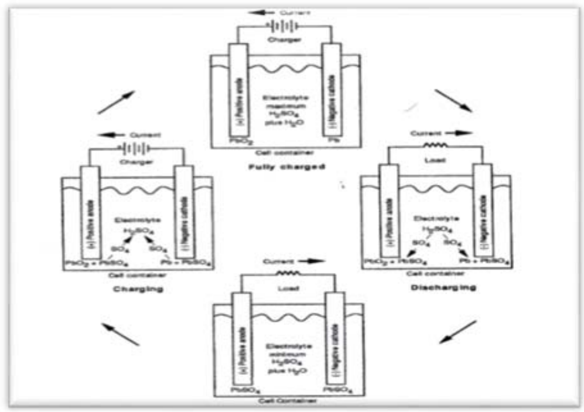

Figure-2. Chemistry of simple lead-acid cell.

When a load is connected across the battery, the voltage of the battery produces an external current flow from positive to negative corresponding to its internal electron flow from negative to positive shown in Figure-2. The observed voltage in galvanic cell is the sum of what happening at the anode and cathode. To make an ideal battery, choose the active material that gave the greatest oxidation potential at the anode coupled with the material that gave the greatest reduction potential at the cathode that were both supportable by a suitable electrolyte material. The chemistry of a very simple lead-acid battery cell that will be examined and it undergoes the four stages, fully charged, discharging, fully discharged and charging. It consist of an electrode made of sponge lead (Pb), another electrode made of lead peroxide (PbO2), and an electrolyte made of mixture of sulphuric acid diluted with water.

VOL. 11, NO. 6, MARCH 2016 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

Table-1. Chemical reactions and single unit voltages of main batteries available to electrical energy storage [6].

Battery type	Chemical reactions at anodes and cathodes	Unit voltage
Lead–acid	$Pb + SO_4^{2} \rightarrow PbSO_4 + 2e^- \; PbO_2 + SO^2{}_4 + 4H^+ + 2e^- \; PbSO_4 \rightarrow + 2H_2O$	2.0 V
Lithium-ion	$C + nLi^+ + ne^- \rightarrow Li_nC \; LiXXO_2 \rightarrow Li_{1-n}XXO_2 + nLi^+ + ne^-$	3.7 V
Sodium–sulfur	$2Na \rightarrow 2Na^+ + 2e^- \; xS + 2e^- \rightarrow xS^{2-}$	~2.08 V
Nickel–cadmium	$Cd + 2OH^- \rightarrow Cd(OH)_2 + 2e^- 2NiOOH + 2H_2O \rightarrow + 2e^- \; 2Ni(OH)_2 + 2OH^-$	1.0–1.3 V
Nickel–metal hydride	$H_2O + e^- \rightarrow 1/2H_2 + OH^- \rightarrow Ni(OH)_2 + OH^- \; NiOOH + H_2O + e^-$	1.0–1.3 V
Sodium nickel chloride	$2Na \rightarrow 2Na + 2e^- \; NiCl_2 \rightarrow + 2e^- \; Ni + 2Cl^-$	~2.58 V

From Table-1 it can be said that, lead acid battery is better than Sodium–sulfur, Nickel–cadmium, Nickel–metal hydride, and Sodium nickel chloride except Lithium-ion. Voltage storage system of lead acid battery is superior in comparison than other types of battery.

EV DESIGN

Basic design

The design approach of modern EVs should include state of the-art technologies from automobile engineering, electrical and electronic engineering, and chemical engineering, should adopt unique designs particularly suitable for EVs and should develop special manufacturing techniques particularly suitable for EVs. Every effort should be made to optimize energy use (Chan, C. and Y. Wong, 2004). There are two basic methods for producing EV's either converted for purpose. For the conversion method, the engine and associated equipment of an existing vehicle are replaced by the electric motor, controller, and batteries. However, in most conversions, the resulting EV has a greater curb weight and may have a higher centre of gravity and other weight distribution differences that can affect handling. Purpose-built or ground-up EV's have more advantages than conversions. In designing an EV from the ground up, the engineers have the opportunity to integrate various components so that they work most efficiently together [7].

Energy storage system

Energy storage is another important component in a hybrid electric drivetrain. It is required to have sufficient peak power and energy capacity to support the operation of the vehicle. At present, almost all the vehicles use chemical batteries as their energy storage.

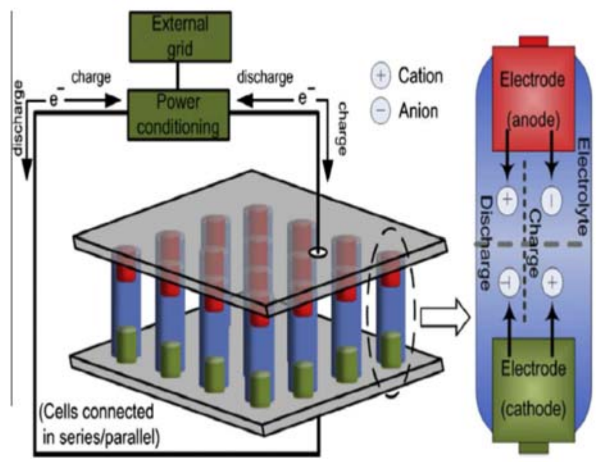

Figure-3. Schematic diagram of a battery energy storage system operation [5].

The rechargeable battery is one of the most widely used EES technologies in industry and daily life. Figure-3 shows the simplified operational principle of a typical battery energy storage system. A BES system consists of a number of electrochemical cells connected in series or parallel, which produce electricity with a desired voltage from an electrochemical reaction. Each cell contains two electrodes with an electrolyte which can be at solid, liquid and viscous states. A cell can bi-directionally convert energy between electrical and chemical energy. During discharging, the electrochemical reactions occur at the anodes and the cathodes simultaneously.

To the external circuit, electrons are provided from the anodes and are collected at the cathodes. During charging, the reverse reactions happen and the battery is recharged by applying an external voltage to the two electrodes Figure-3. Batteries can be widely used in different applications, such as power quality, energy management, ride-through power and transportation systems. The construction of battery energy storage systems takes a relatively short time period. The location

VOL. 11, NO. 6, MARCH 2016 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

for installation can be quite flexible, either housed inside a building or close to the facilities where needed. Currently, relatively low cycling times and high maintenance costs have been considered as the main barriers to implementing large-scale facilities. The disposal or recycling of dumped batteries must be considered if toxic chemical materials are used. Furthermore, many types of battery cannot be completely discharged due to their lifetime depending on the cycle Depth-of-Discharge

Grid connection

The zener diodes are absorbed transient voltages resulting when the MOSFETs turn off. Energy stored in the inductance of the primary winding must go somewhere when the MOSFETs turnoff and the magnetic field collapse. Zener diodes provide a safe way to dissipate this stored energy. When the inverter circuit runs unloaded then the zener diodes may become warm. Interestingly, these same diodes will cool off when an AC load is connected. It's actually testing this inverter circuit and monitoring it performance loaded and unloaded.

POWER FLOW CONTROL

AC power control

Power inverter is electrical device that convert direct current (DC) to alternating current, the converted AC can be at any required voltage and frequency with the use of appropriate transformer, switching and control circuit. These inverters use the same basic architecture as the square wave output circuits. But instead of delivering a 50 Hz to 60 Hz square wave, they drive the load with a pulse width modulated rectangle wave at a frequency above the audio range.

In response to concerns about energy cost, energy dependence, and environmental damage, a rekindling of interest in electric vehicles (EV's) has been obvious [7]. The progress and features of different propulsion systems are reviewed. Power semiconductor devices suitable for electric vehicle controller applications are compared [6]. This paper explores the benefits and discusses control schemes of the cascade inverter for use as an EV motor drive and the diode-clamped inverter as a series motor drive [8]. The controls of two power stages are properly designed and digitally realized using a common digital signal processor [6]). The requirements of EVs on electric motor drives are presented. The efficiency and response of the power train, namely of the electric motor (EM), are very important aspects on the correct sizing and project of an electric vehicle [8]. With the aim to assess power electronic architectures for electric vehicles, modeling of power electronics is discussed in this paper. Drive train topologies are introduced, the investigated power electronic components are described, and the modeling process is discussed. The development of a model of an electric vehicle (EV) with a battery-powered inverter controlled induction machine drive system. A maximum efficiency control strategy for the induction machine is proposed to optimize EV performance. The reliability of electronic systems is a major constraint depending on electromagnetic interference levels.

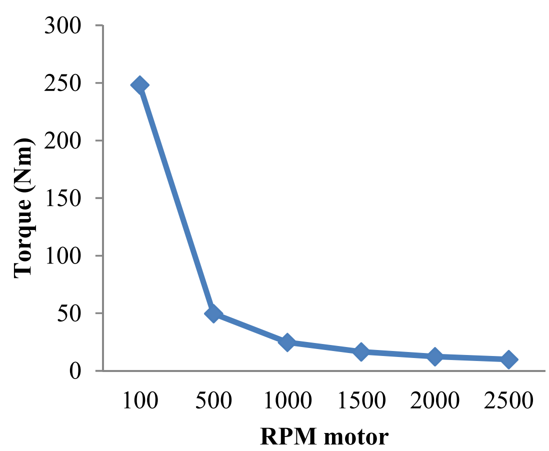

Figure-4. Torque vs RPM curve of Induction motor.

From Figure-4 it can be said that, when the torque was nearly 248Nm at that time motor rpm was around 150. After that, motor rpm was increased then torque was gradually decreased according to the figure 4. It can be observed that, if the torque is increased then motor rpm will be decreased. The required torque of the motor and torque at the wheel can be identified from this figure. Furthermore, the electric vehicle speed depends on the torque ratio and starting torque must be enough to turn the drivetrain system and make the wheel rotate.

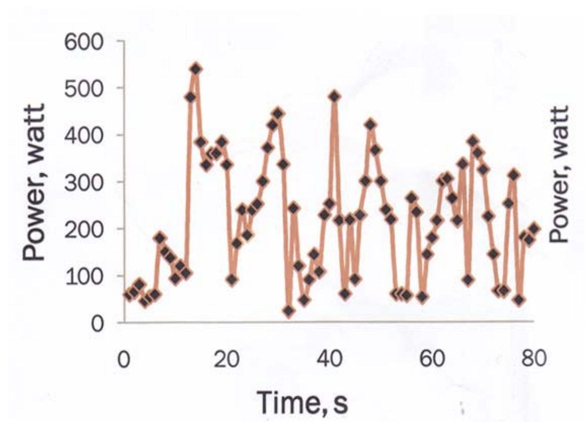

Figure-5. Power vs. time.

From Figure-5 it can be observed that, power is directly related with time. The power was fluctuated according to time base. From Figure 5, the power pick was highest (550watt) at that moment when the time was around 18 sec. The second highest power pick was 500 watt and time was around 40sec.

ARPN Journal of Engineering and Applied Sciences

CONCLUSIONS

Optimized energy management strategies are key elements to the improved performance of electric vehicle and characterization of the electric vehicle requires a detailed understanding of the energy management modes in which a particular vehicle operates. Technological advancements in the energy density, power density and lifetime of electrochemical energy storage batteries have improved the performance and lifecycle cost prospects of electric vehicle. The impact of lateral acceleration and the shape of the vehicle characteristic on the input power to the electric drivetrain. A reduction of the under steer gradient in traction reduces the battery power demand for the same value of lateral acceleration.

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