International Journal for Innovative Engineering and Management Research
A Peer Revieved Open Access International Journal
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Volume 06, Issue 13, Page No: 319 – 326.

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DOUBLE MODE ELECTRICAL CONVERTER FOR PV FED EV/HEV APPLICATIONS

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ABSTRACT---

In recent years, renewable energy sources such as photovoltaic (PV), wind, fuel cell, etc gain importance due to the limitations of conventional energy sources. Renewable energy sources play an important role in rural areas where the power transmission from conventional energy sources is difficult. Other advantages of renewable energy sources are clean, light and does not pollute atmosphere. In order to meet the required load demand, it is better to integrate the renewable energy sources with the load. Hybrid electric vehicles (HEVs) powered by electric machines and an internal combustion engine (ICE) are a promising mean of reducing emissions and fuel consumption without compromising vehicle functionality and driving performances. The proposed integrated circuit allows the permanent magnet synchronous motor to operate in motor mode or acts as boost inductors of the boost converter, and thereby boosting the output torque coupled to the same transmission system or dc-link voltage of the inverter connected to the output of the integrated circuit. Electric Motors, those are used for EV propulsion must have high efficiency for maximum utilization of the energy from batteries and/or fuel cells. Motor control algorithm for a dual power split system is proposed for hybrid electric vehicles (HEV). A new control technique for the proposed integrated circuit under boost converter mode is proposed to increase the efficiency. Since the light load performance is in recent focus of interest, appropriate algorithms to improve light load efficiency were implemented. The proposed control technique is to use interleaved control to significantly reduce the current ripple and thereby reducing the losses and thermal stress under heavy-load condition. In order to evaluate performance of the control algorithm, HEV simulator is developed using MATLAB/ Simulink. Finally PV fed converter model is connected to induction motor and check the speed torque characteristics of IM. Matlab/Simulink model is developed and simulation results are presented.

Index Terms—RES, hybrid electric vehicles (HEV), boost converter, electric vehicles (EV), photovoltaic (PV), an internal combustion engine (ICE)

I. INTRODUCTION

PV technologies are expected to become an attractive power source for automotive applications because of their cleanness, high efficiency, and high reliability. Although there are various PV technologies available for use in automotive systems, many commercial hybrid electric vehicle (HEV) systems use a traditional bidirectional dc-dc converter to interface the battery and the inverter dc bus.

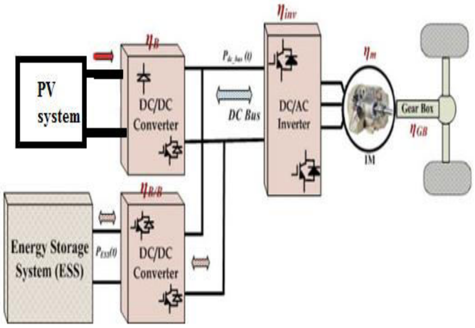

Fig.1 Block diagram of the PV based HEV

There is growing interest in electric vehicle (EV) and hybrid electric vehicle (HEV) technologies because of their reduced fuel usage and greenhouse emissions [1]–[3]. PHEVs have the advantage of a long driving range since fuel provides a secondary resource. Connection to the electric power grid allows opportunities such as ancillary services, reactive power support, tracking the output of renewable energy sources, and load balance. For purposes of this paper, plug-in vehicles will be lumped together with EVs. Most EV charging can take place at home overnight in a garage where the EV can be plugged in to a convenience outlet for Level 1 (slow) charging. Level 2 charging is typically described as the primary method for both private and public facilities and requires a 240 V outlet.

An electric vehicle is an emission free, environmental friendly vehicle. However, the electric vehicles remain unpopular among the consumers due to their lack of performance and their inability to travel long distances without being recharged. So, vehicle that embraces both the performance characteristics of the conventional automobile and the zero-emission characteristics of the electric vehicles are greatly being anticipated by the general consumers and the environmentalists alike. Technically, the quest for higher fuel economy is shaped by two major factors: how efficiently a power train converts fuel energy into useful power, and how sleek a vehicle is in terms of mass, streamlining, tire resistance, and auxiliary loads. On the other hand, vehicle functionality and comfort are shaped by various other factors, many of which run counter to higher fuel economy. Examples abound, from the way torque converter sacrifices efficiency to provide better shift smoothness and responsiveness to the wide variety of features that add mass to a vehicle.

II. HEV CONFIGURATIONS

A brief description about various HEV configurations available in the market is presented. The three main configurations are the series, parallel and the dual-mode configurations and the explanation of each one of them with their merits and demerits follows.

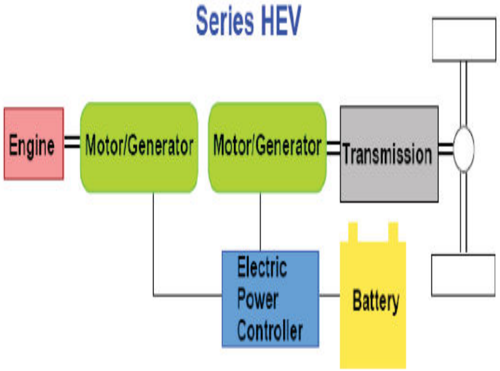

Fig.2 Series HEV drive train

In series HEV configuration, only the electric motor is connected to the drive train and thus the vehicle is entirely driven by the electric motor. The Internal Combustion (IC) engine drives an electric generator (commonly known as alternator), which then supplies the electric power to the motor and battery pack. The IC engine will turn off if the battery is fully charged. In some cases, the electric power supply for the electric motor can come both from the battery and the engine generator set. As only the electric motor is connected to the drive train, the IC engine can run at an optimum speed to run the generator thus greatly reducing the emissions. The batteries can either be charged off-board, by external DC power link from the electric-grid, or on-board, with the help of an alternator and an IC engine. In this setup, it is possible to design the operation such that the IC engine never idles and thus the overall emissions are reduced. The schematics of series HEV is shown in Figure 2.

It can be seen that the IC engine is connected to the alternator (generator) which in turn is connected to the battery pack and electric motor through an electronic control unit. This scheme allows the electric motor to get its power from either battery pack or the alternator or both as per the battery state of charge and vehicle acceleration requirements [4-6].

B. Parallel HEV Configuration

In the parallel HEV configuration there are two power paths for the drive train, while one comes from the engine the other comes from the electric motor. During short trips the electric motor can power the vehicle, while during long drives the IC engine can power the vehicle. The vehicle can thus have engine only, motor only, or a combination of engine and motor mode of operation. The electric motor can also assist the engine during hill climbs and vehicle accelerations, thus the rating of the IC engine can be reduced. This configuration is illustrated in Figure 3.

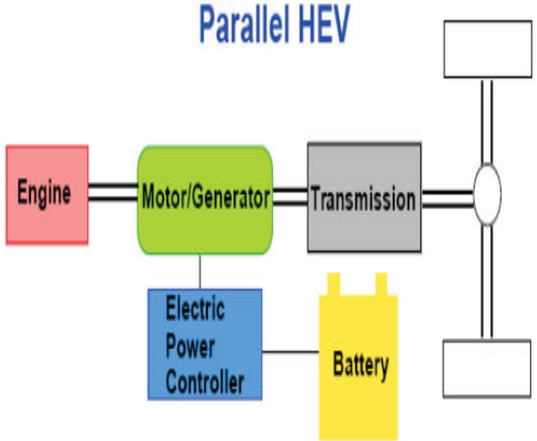

Fig.3 Parallel HEV drive train

In parallel HEV configuration, the drive train is connected to the electric motor and engine through a mechanical coupling or an angle gear. These vehicles do not require a generator (as in the case of series HEV configuration) and they can be connected to an electric grid (off-board) for recharging the batteries. The electric motor can be made to act as generator via a mechanical clutch which can then be used for regenerative braking. Both the gas-powered engine and the electric motor can turn the transmission simultaneously, and the transmission, of course, turns the wheels. The fuel tank and gas engine and the batteries and electric motor connect independently to the transmission—as a result, in a parallel hybrid; both the electric motor and the gas engine can provide power.

III. PROPOSED INTEGRATED CIRCUIT AND CONTROL TECHNIQUE

A. Proposed Integrated Inverter/Converter Circuit

In Fig. 4, *C*in and *C*out can stabilize the voltage when input and output voltages are disturbed by source and load, respectively. Diode (*D*) is used for preventing output voltage impact on the input side. When the integrated circuit is operated in inverter (motor) mode, relay will be turned ON and six power devices are controlled by pulse width modulation (PWM) control signals

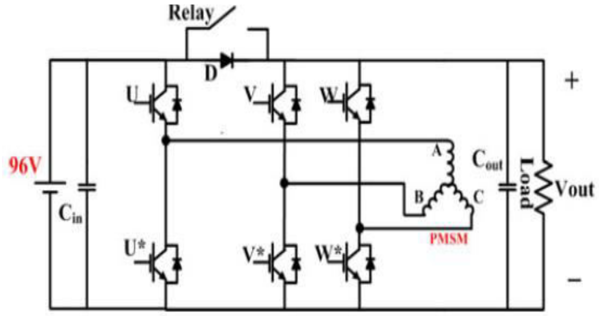

Fig. 4 shows the integrated circuit for dual-mode control

When the proposed integrated circuit is operated in the converter mode, relay is turned OFF. And a single-phase or interleaved control method will be applied to control of the power devices depending upon the load conditions.

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B. Modeling and Controller Design under Boost Mode

This section will introduce the model of boost converter and derive the transfer function of the voltage controller. Fig.5 shows the non ideal equivalent circuit of the boost converter, it considers non ideal condition of components: inductor winding resistance *RL*, collector-emitter saturation voltage *V*CE, diode forward voltage drop *VD* , and equivalent series resistance of capacitor *R*esr .

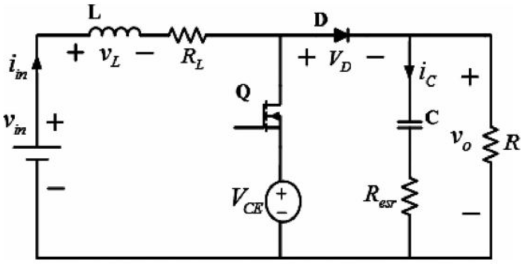

Fig.5 Equivalent circuit of the boost converter

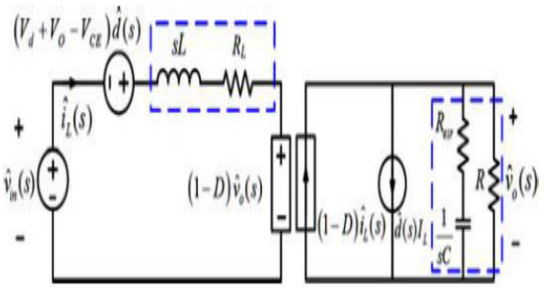

Fig.6 Small-signal equivalent circuit

Analysis of the boost converter by using the state-space averaging method [4], small-signal ac equivalent circuit can be derived, as shown in Fig. 6.

$$G_{vd}(s) = \frac{-6.737 \times 10^{-5} s^2 + 0.06827 s + 2498}{2.004 \times 10^{-5} s^2 + 0.00409 s + 3.242} \quad (1)$$

Fig. 7 shows the block diagram of voltage loop, using a proportional-integral (PI) controller for the compensator. In this paper, the switching frequency is 20 kHz and voltage loop band width will be less than 2 kHz. And the phase margin should be more than 45◦ to enhance the noise immunity. For the designed controller shown in (2

$$C(s) = \frac{0.0248387 s + 13.073}{s} \quad (2)$$

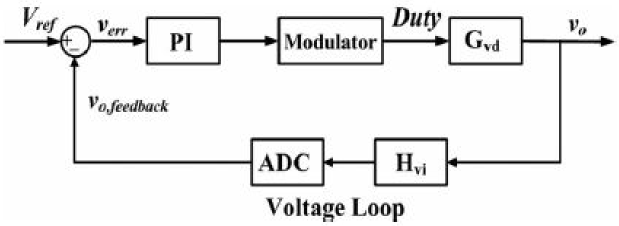

Fig.7 Block diagram of voltage loop

IV. PHOTOVOLTAIC (PV) SYSTEM

The power that one module can produce is seldom enough to meet requirements of a home or a business, so the modules are linked together to form an *array*. Most PV arrays use an inverter to convert the DC power produced by the modules into alternating current that can power lights, motors, and other loads. The modules in a PV array are usually first connected in series to obtain the desired voltage; the individual strings are then connected in parallel to allow the system to produce more current The PV array is made up of number of PV modules connected in series called string and number of such strings connected in parallel to achieve desired voltage and current. The PV module used for simulation study consists of 36 series connected polycrystalline cells. In the crystalline silicon PV module, the complex physics of the PV cell can be represented by the equivalent electrical circuit shown in below figure. For that equivalent circuit, a set of equations have been derived, based on standard theory, which allows the operation of a single solar cell to be simulated using data from manufacturers or field experiments.

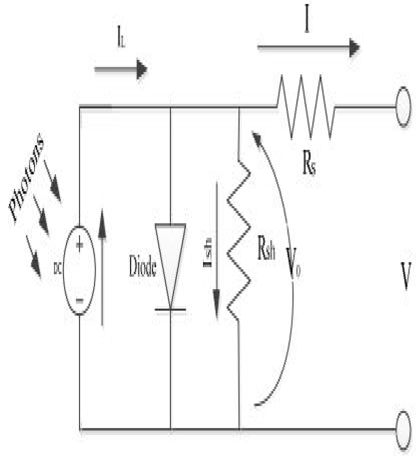

Fig.8 Equivalent electrical circuit of a PV module

The series resistance RS represents the internal losses due to the current flow. Shunt resistance Rsh, in parallel with diode, this corresponds to the leakage current to the ground. The single exponential equation which models a PV cell is extracted from the physics of the PN junction and is widely agreed as echoing the behavior of the PV cell. The number of PV modules connected in parallel and series in PV array are used in expression. The Vt is also defined in terms of the ideality factor of PN junction (n), Boltzmann's constant (KB), temperature of photovoltaic array (T), and the electron charge (q). Applied a dynamical electrical array reconfiguration (EAR)strategy on the photovoltaic (PV) generator of a grid-connected PV system based on a plant-oriented configuration, in order to improve its energy production when the operating conditions of the solar panels are different. The EAR strategy is carried out by inserting a controllable switching matrix between the PV generator and the central inverter, which allows the electrical reconnection of the available PV modules.

V. SIMULATION RESULTS

Here the simulation carried by two different cases they are 1) Proposed interleaved boost converter multiplier module 2) PV as input source of proposed converter with interleaved boost converter

Case-1Proposed interleaved boost converter

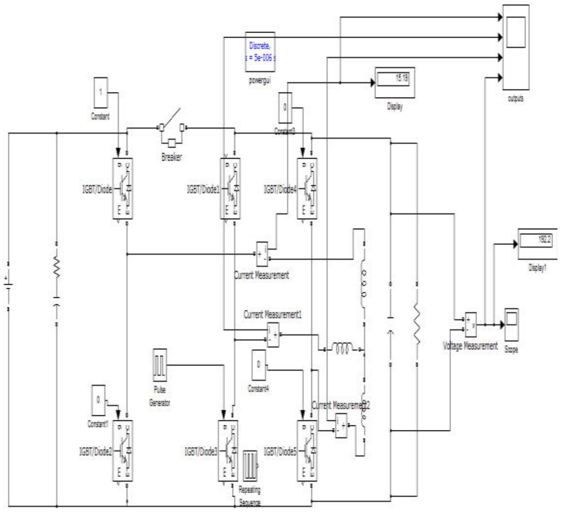

Fig.9 Matlab/simulink model of the integrated circuit and controller

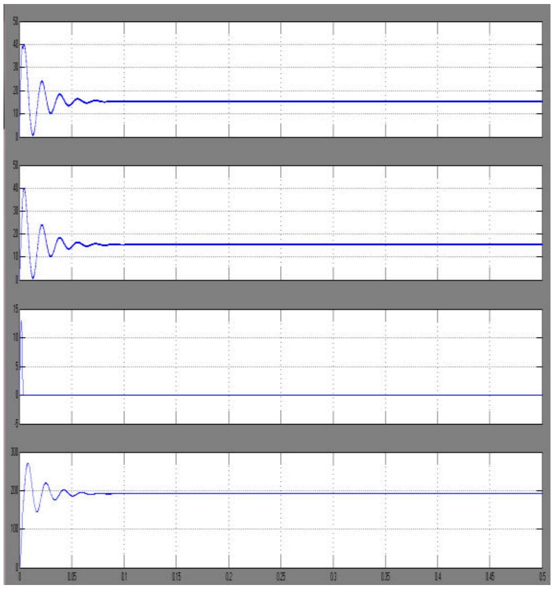

Fig.10 measured current with and without interleaved control, Single-phase interleaved boost converter

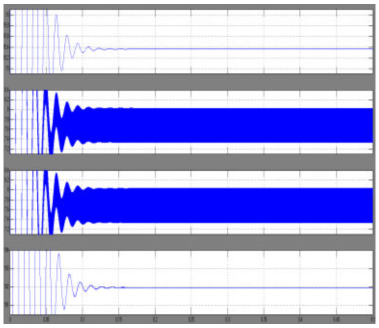

Fig.11Measured current with and without interleaved control, Two-phase interleaved boost converter

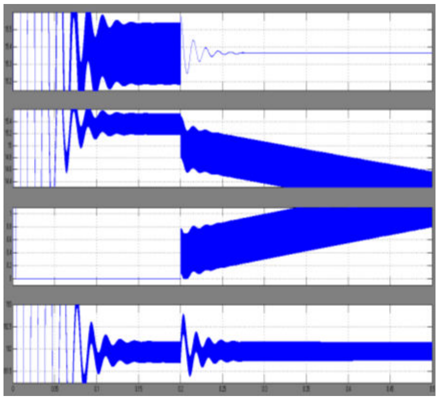

Fig. 12simulated waveforms for the transition between single-phase control and two-phase interleaved control from two-phase interleaved to single-phase modes.

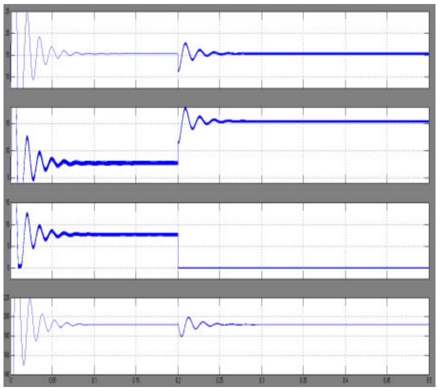

Fig. 13simulated waveforms for the transition between single-phase control and two-phase interleaved control single-phase to two-phase interleaved modes

Case-2 proposed interleaved boost converter with PV source

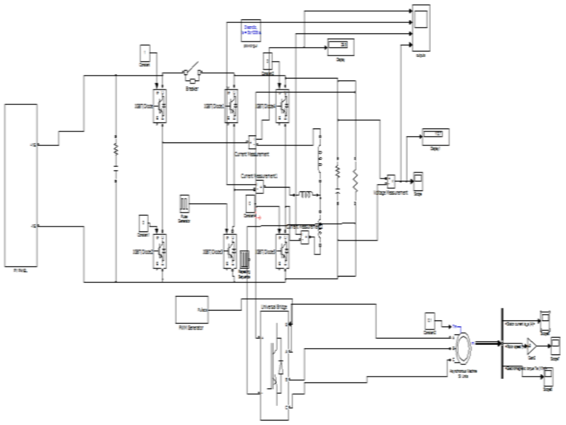

Fig.14 Matlab/simulink model of the integrated circuit and controller with PV as input source

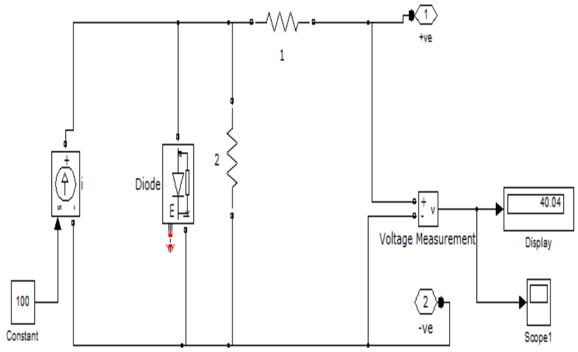

Fig.15 simulation model of PV system

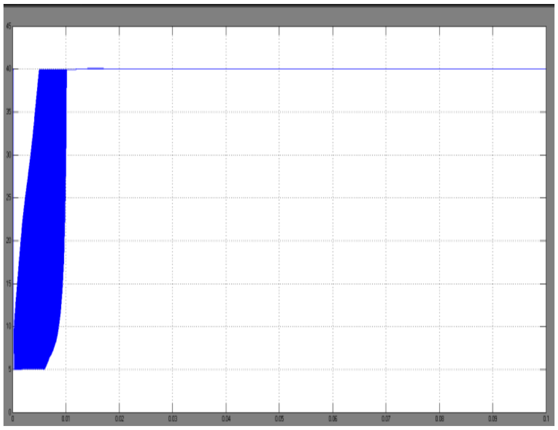

Fig.16 shows simulated PV output voltage

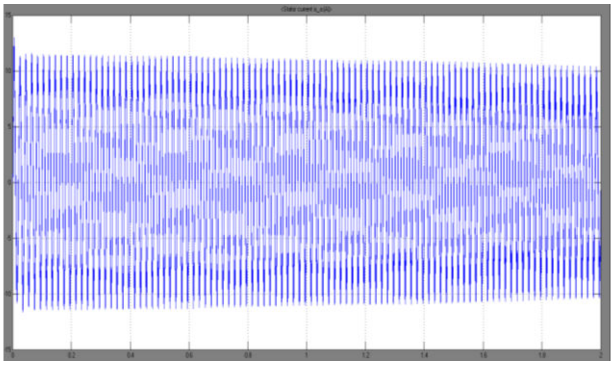

Fig.17 Armature current of induction motor

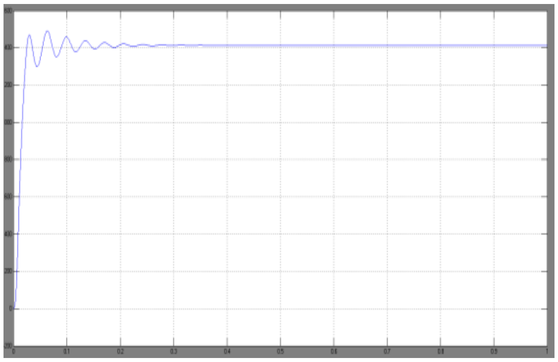

Fig.18 Speed of a induction motor

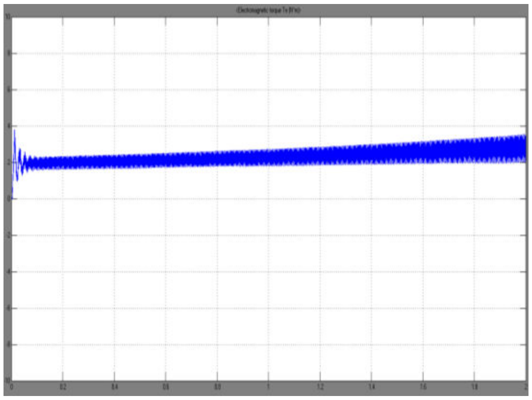

Fig.19 electromagnetic torque of a induction motor

VI. CONCLUSION

An HEV intelligently gets around the individual problems associated with the gasoline engine and the electric vehicle. It diminishes the production of emissions and the use of fuel. The problem of batteries for the electric vehicle is conquered. An HEV charges itself – it never has to be plugged in. When not in use providing power, the motor can run as a generator to transfer energy from regenerative braking and from the gasoline engine to the batteries. The only recharging necessary is refueling by going to the gas station. Also, there is not the same demand on the batteries as there would be in an electric vehicle, where the batteries must store all the energy the car needs. Proposal of a new integrated inverter/converter circuit of motor drives with dual-mode control for EV/HEV applications to significantly reduce the volume and weight, proposal of a new control method for the integrated inverter/converter circuit operating in boost converter mode to increase the efficiency, verification of the proposed integrated inverter/converter circuit. The above proposed converter tested by adding the induction motor and verified the speed torque characteristics.

REFERENCES

[1] M. Ehsani, Y. Gao, S. E. Gay, and A. Emadi, *Modern Electric, Hybrid Electric, and Fuel Cell Vehicles*. Boca Raton, FL: CRC Press, 2005.

[2] A. Emadi,M. Ehsani, and J.M.Miller, *Vehicular Electric Power Systems:Land, Sea, Air, and Space Vehicles*. New York: Marcel Dekker, 2003.

[3] J. Larminie and J. Lowry, *Electric Vehicle Technology Explained*. New York: Wiley, 2003.

[4] A. Y. Saber and G. K. Venayagamoorthy, “One million plug-in electric vehicles on the road by 2015,” in *Proc. IEEE Intell. Trans. Syst. Conf.*, Oct. 2009, pp. 141–147.

[5] M. Maskey, M. Parten, D. Vines, T. Maxwell, "An intelligent battery management system for electric and hybrid electric vehicles,"IEEE 49th Vehicular Technology Conference, 2, 1999, pp. 1389-1391.

[6] L. James and L. John, “Electric Vehicle Technology Explained”, John Wiley & Sons, England. 2003.

[7] M. Habib Ullah, M. T. Islam, Madeep Singh, N. Misran, "Design of A Microwave Amplifier for Wireless Application", American Journal of Applied Sciences, Volume 9, Issue 1, 2012, pp. 32-39.

[8] Sharif M. Raihan, M. Habib Ullah, Riza Muhida, "A Prototype Design to Maintain Temperature and Humidity in an Open Compound Restaurant", European Journal of Scientific Research, Vol.63 No.2, 2011, pp.164-171.

[9] M. Habib Ullah, Mandeep Sing, Sumazly Sulaiman, M. Shamim Shumon M. Islam, "Hardware Prototyping of Root Raised Cosine FIR Filter for 2x2 MIMO Channel Sounder", Australian Journal of Basic and Applied Sciences, 5(11), 2011, pp. 375-382.

[10] M. A. P. Andrade, L. Schuch, and J. R. Pinheiro, “Generalized switching logic scheme for CCM-PFC interleaved boost converters,” in *Proc. IEEE Power Electron. Spec. Conf.*, 2004, pp. 2353–2359.

[11] Y. Gu and D. Zhang, “Interleaved boost converter with ripple cancellation network,” *IEEE Trans. Power Electron.*, vol. 28, no. 8, pp. 3860–3869, Aug. 2013.

[12] Y. T. Chen, S. Shiu, and R. Liang, “Analysis and design of a zero-voltageswitching and zero-current-switching interleaved boost converter,” *IEEE Trans. Power Electron.*, vol. 27, no. 1, pp. 161–173, Jan. 2012.

[13] T. Grote, H. Figge, N. Fr¨ohleke, W. Beulen, F. Schafmeister, P. Ide, and J. B¨ocker, “Semi-digital interleaved PFC control with optimized light load efficiency,” in *Proc. IEEE Appl. Power Electron. Conf.* , 2009, pp. 1722–1727.