DESIGN AND IMPLEMENTATION OF MICRO CONTROLLER BASED PLUGGING BRAKING IN ELECTRIC/ HYBRID ELECTRIC VEHICLE

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Abstract: *The Hybrid Electric Vehicle has become one of the most promising vehicles in the automobile industry due to its energy saving ability and low emission of harmful pollutants. Plugging is used for instantaneous braking or quick reversal of the vehicle. This paper proposes a novel approach for design and fabrication of micro controller based plugging braking technique used in ELECTRIC VEHICLE (EV) / HYBRID ELECTRIC VEHICLE (HEV). To realize this technique, an embedded systems programming is developed using KEIL and PROTEUS softwares. The status of the vehicle motion is indicated by means of Liquid Crystal Display (LCD) and Light Emitting Diode (LED). The simulation and experimental results ensure the feasibility and advantages of the new approach.*

Key Words: *charging Embedded system, Plugging, Micro controller, KEIL compiler, PROTEUS Software, Hybrid Electric Vehicle.*

1. Introduction

With the spiraling fuel costs and the environmental concerns due to the use of conventional, non-renewable fossil fuels, automobile engineers have had to develop more economical and environmentally safer alternatives to the internal combustion engine that powers most cars and huge trucks. This has led to the birth of the hybrid automobile. Hybrid Electric Vehicle (HEV) as shown in figure.1 combines a conventional internal combustion engine (ICE) propulsion system with an electric propulsion system. The presence of the electric power train is intended to achieve either better fuel economy than a conventional vehicle, or better performance or both. Emissions from hybrid electric motor vehicles are also substantially lower than conventionally powered motor vehicles."Hybrid-Electric Drive" (HED) systems are promising up to 30 – 40 percent savings, compared to current internal-combustion engines. [1]. By electronically controlling each wheel, HED systems dynamically manage the drive torque going to each wheel accommodating any driving condition on and off-road. While HED systems have great benefits in fuel economy, improved performance and weight saving. The US Army expects hybrid-electric powered trucks and the hybrid-electric Future Combat Systems (FCS) helps the service attain its stated objective of 75 percent lower fuel consumption by 2020. This paper has been organized as follows. Section II describes Electrical breaking techniques used in vehicles. Section III presents proposed block diagram of plugging technique. Section IV demonstrates the hardware implementation of braking technique and results.

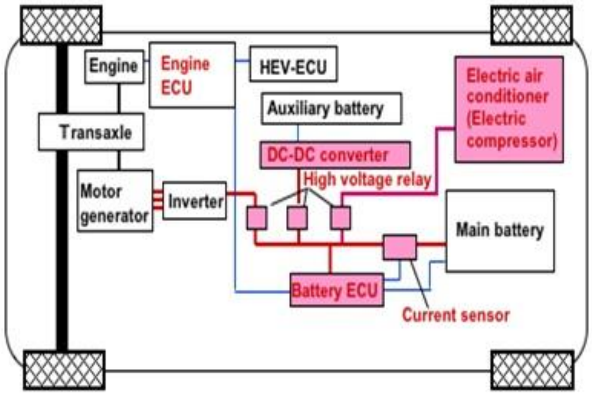

Fig.1 Block diagram of Hybrid Electric Vehicle

2. Electrical Braking Techniques

There are two different types of braking techniques. (i) Mechanical braking and (ii) Electrical braking. In order to stop the vehicle, brake pedal has to be pressed. When pedal is pressed the brake pads holds the wheel of the vehicle tightly and the wheel stops rotating. The entire kinetic energy is thus wasted as heat which causes wear and tear of the tire and brake pads demands frequent replacement. In order to avoid this frequent replacement, electrical braking technique need to be adopted which could be advantageous than mechanical braking. If electrical braking is considered alone usage of brake pads is reduced considerably.[2] Electrical braking is further classified into three types. They are (a) Regenerative braking (b) Plugging (c) Dynamic or Rheostat braking Regenerative braking is a way of slowing a vehicle down where some or all of the vehicle's kinetic energy is saved rather than being wasted as heat. Stoppage of the motor is done more rapidly by using a method called plugging. It consists of suddenly reversing the armature current by reversing the armature terminals of the drive. The curves of figure.2 enable us to compare plugging and dynamic braking for the same initial braking current. Note that plugging stops the motor completely after an interval $2T_o$. On the other hand, if dynamic braking is used, the speed is still 25 percent of its original value at this time. [3]

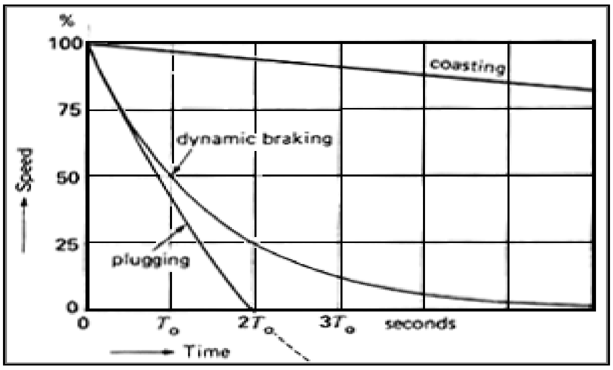

Fig.2. Speed versus time curves for various braking methods.

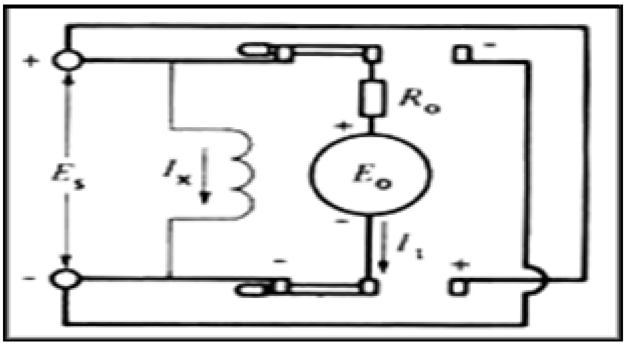

Fig.3 D.C Motor Diagram under motoring condition

Under normal motor conditions, armature current $\mathbf{I_1}$ of Permanent Magnet Direct current (PMDC) motor as shown in figure.3 is given by

$$\mathbf{I_1 = (E_s - E_0)/\ R_o} \qquad \textbf{(1)}$$

Where $\mathbf{R_0}$ is the armature resistance. When armature terminals of the PMDC are suddenly reversed, the net voltage acting on the armature circuit becomes $(\mathbf{E_s + E_0})$. The so-called counter-emf $\mathbf{E_0}$ of the armature is no longer counters to anything but actually adds to the supply voltage $\mathbf{E_s}$. [4]-[6]. This net voltage would produce an enormous reverse current, perhaps 50 times greater than the full-load armature current and initiate an arc around the commutator, destroying segments, brushes, and supports, even before the line circuit breakers could open. To prevent such a catastrophe, reverse current must be limited by introducing a resistor R as shown in figure.4 in series with the reversing circuit.

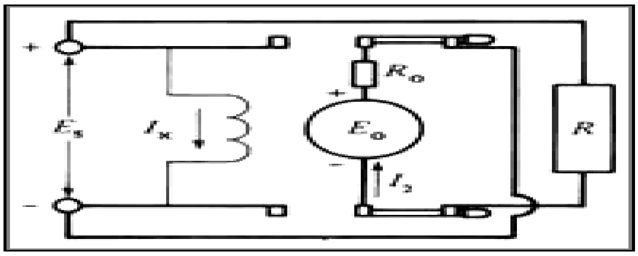

Figure.4 D.C Motor Diagram under Plugging condition

Under Plugging condition, armature current $\mathbf{I_2}$ of PMDC motor as shown in Figure.4 is given by

$$\mathbf{I_2 = (E_s + E_0)/\ R_o} \qquad \textbf{(2)}$$

3. Power dissipated in the rotor of D.C motor is $\boldsymbol{P = I_2^2\, R_o}$ $\;(\mathbf{3})$ which is very large and may damage the motor too. Hence heat sink is connected along with the drive for cooling purpose. With this plugging circuit, a reverse torque is developed and stops the drive with in a short span of time. As soon as the motor stops, armature circuit must be disconnected from supply, otherwise it will begin to run in reverse direction.

3. Proposed Block diagram of Charging system

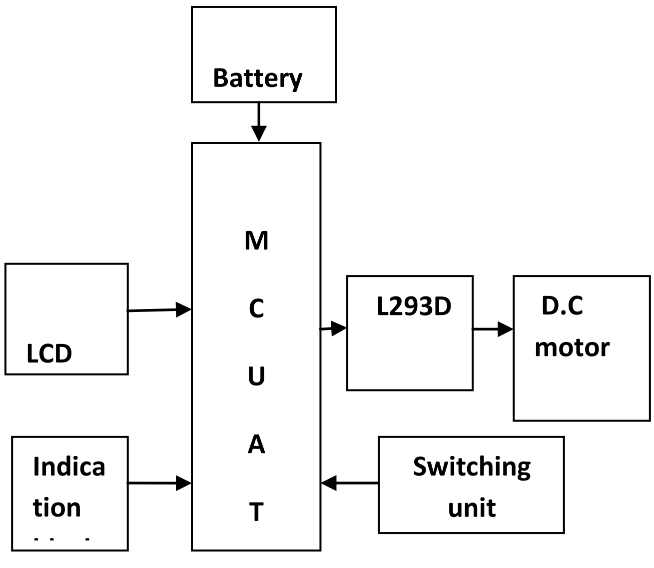

Fig.5 Block diagram of proposed plugging Technique

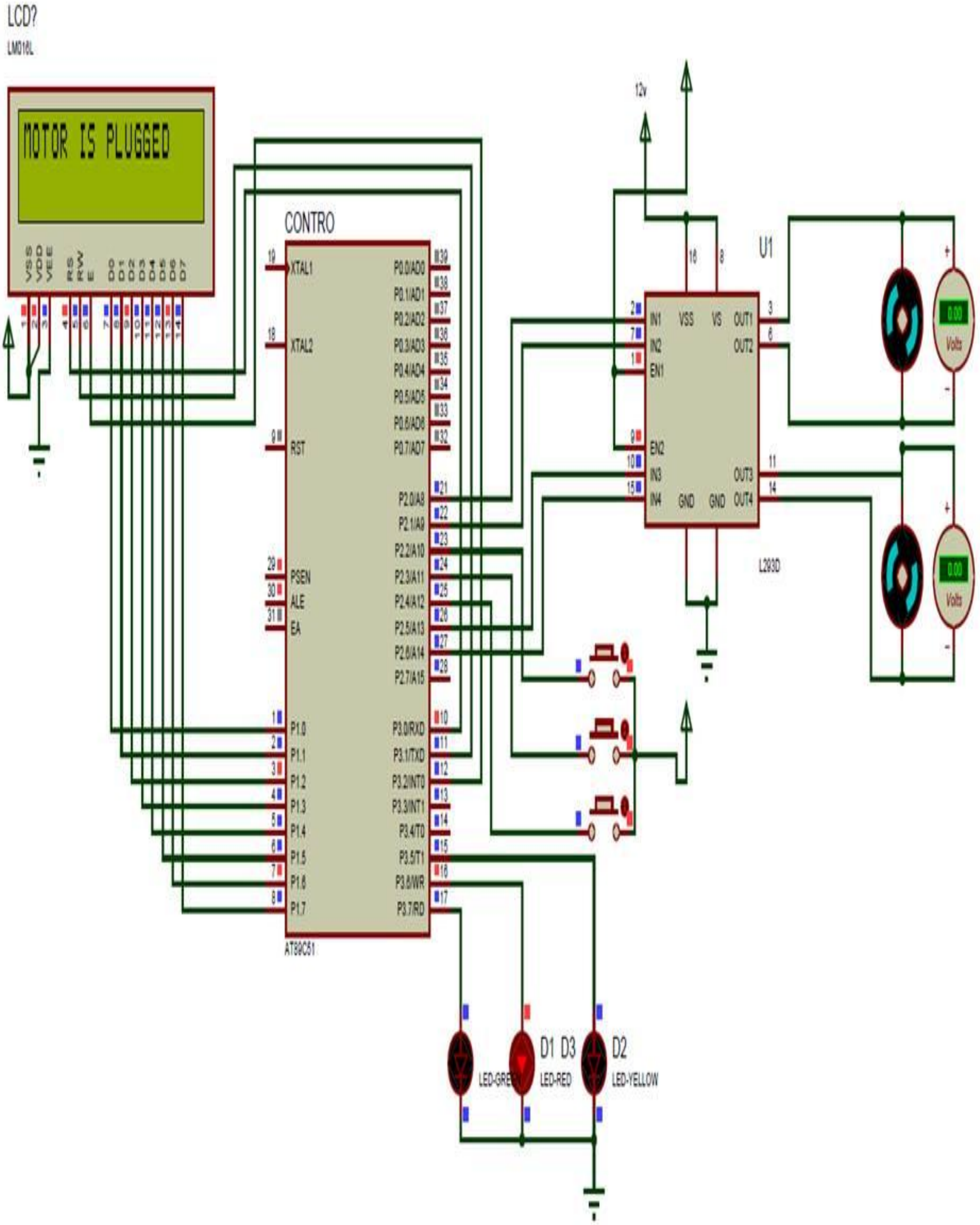

Fig.6 Simulation diagram of proposed Plugging Technique

Block diagram of the proposed plugging technique and its simulated diagram are shown from figure.5 and figure.6 respectively. Instructions are executed by performing the following operations. Switch ON the power supply by pressing the BLUE button. Then the vehicle gets energized and thus all the blocks gets the power supply. LCD initially displays its initial instructions for moving the vehicle in required direction. The instructions which will be displayed by the LCD are (i) WELCOME (ii) PRESS GREEN TO MOVE FORWARD (iii) PRESS RED TO BRAKE (iv) PRESS YELLOW TO MOVE REVERSE. Then the vehicle remains in idle state until and unless any button is pressed. If no button is pressed the micro controller does not sends any signals i.e., inputs to the driving unit. Hence as there are no inputs there will be no output from driving unit i.e., L293D. By pressing either GREEN or YELLOW buttons microcontroller sends its output to the driving unit according to the program dumped into it. These outputs acts as inputs for driving unit and thus it produces corresponding outputs .If GREEN button is pressed then positive supply appears at output terminals of the driving unit and motors starts rotating in forward direction and thus the vehicle moves forward. Then LCD displays the status of the vehicle i.e., “MOVING FORWARD” and also the GREEN LED glows which indicates its status. If YELLOW button is pressed negative supply appears at output terminals and hence motor rotates in reverse direction and thus the vehicle moves reverse. LCD displays the status of the vehicle i.e., “MOVING REVERSE” and also the YELLOW LED glows. If RED button is pressed negative supply appears at output terminals of the driving unit for a short duration (delay given in the program i.e10 ms) [7]-[12]. After the delay time is completed the voltage at the output terminals of the driving unit becomes zero and hence motors rotates in reverse direction for a short time and stops.LCD displays the status of the vehicle i.e., “MOTOR IS PLUGGED” and also the RED LED glows which indicates its status. If RESET button is pressed then the vehicle gets re-started and the above procedure repeats. At last switch OFF the power supply. This is quite innovative and user friendly method which is applicable to electric and hybrid electric vehicles.

4. Hardware implementation of the plugging Technique

Fabricated model of the proposed plugging technique for Electric/ Hybrid Electric Vehicle is shown in Figure.7. The status of the Vehicle under different conditions is shown from figure 8 and figure.9 respectively. Figure.10 shows the variation of plugging time for different speeds of the vehicle.-[13]-[16].

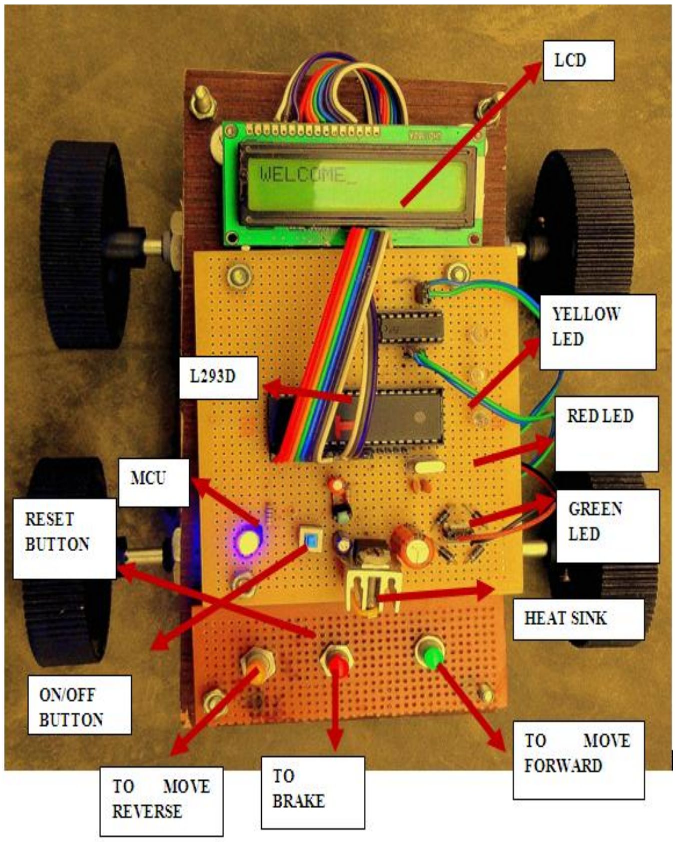

Fig.7 Hard ware implementation of proposed Plugging Technique

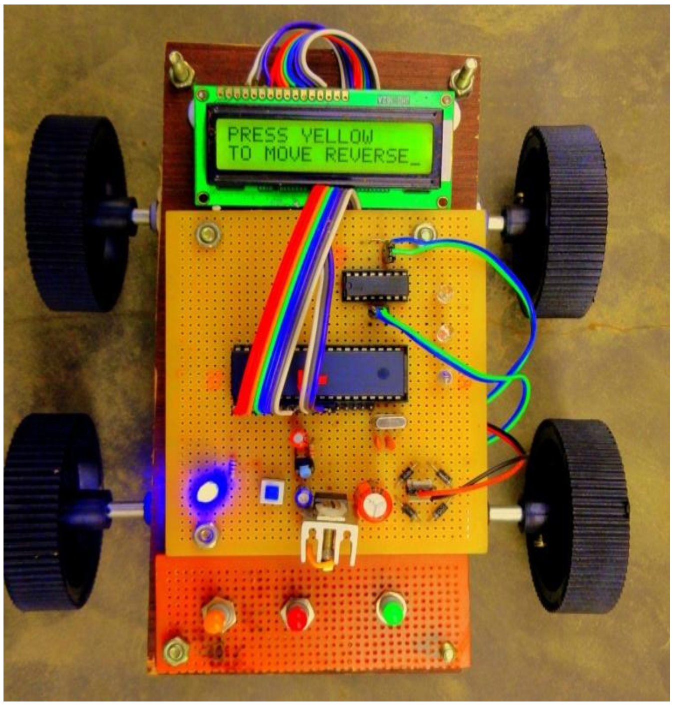

Fig.8 LCD displays when motor is propelling in forward direction

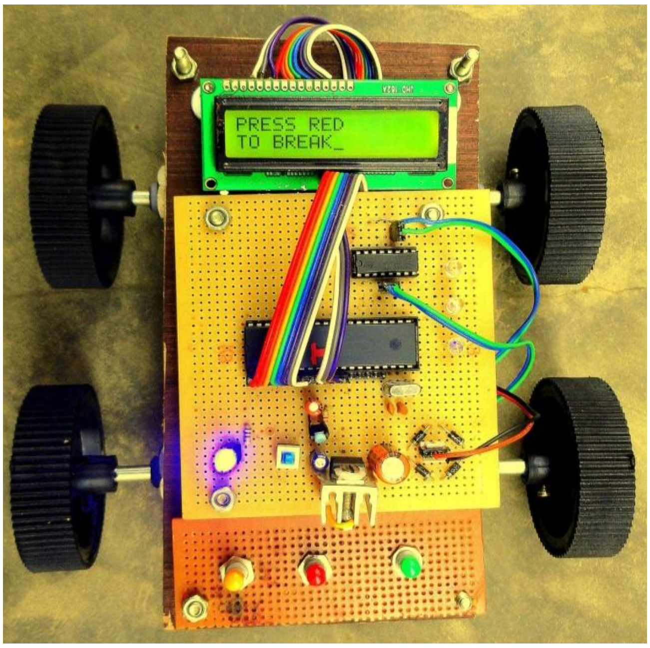

Fig.9 LCD displays when motor is plugging

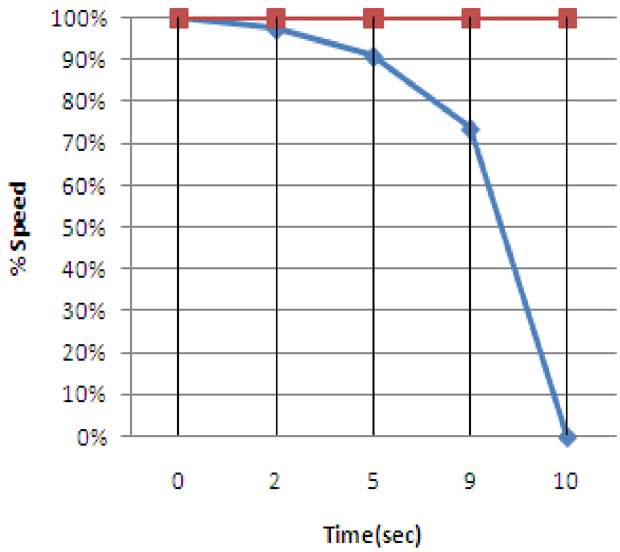

Fig.10 Speed versus time curves for proposed plugging technique

5. Conclusion

Micro controller based plugging braking in electric/ hybrid electric vehicle is realized and fabricated. Here vehicle is operated manually and three switches are placed (forward, brake, reverse). The vehicle remains in idle condition until any button is pressed. When the power supply is switched ON the vehicle display gets started displaying "WELCOME" "PRESS GREEN TO MOVE FORWARD ", "PRESS RED TO BREAK", "PRESS YELLOW TO MOVE REVERSE". By pressing the appropriate switch desired operation is achieved. The vehicle is tested in the laboratory and results are satisfactory. This is a simple heuristic methodology, a user-friendly and fast-acting system for use in controlling hybrid auto-rickshaws and hybrid cars. In future this circuit can be interfaced to the Personnel computer and control can be viewed by vehicle driver.

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References

1. **Xialonghe and Hodgosonj.W** "*Modelling and simulation for hybrid electric vehicles*". IEEE Transactions on Intelligent Transportation Systems, Volume3,Issue 4, p.p:235 – 243 (2012).

2. **Y.gao, I.Chen and M.Ehsani** "*Investigation of the effectiveness of regenerative braking for EV & HEV,SAE international SP*" IEEE transactions on modelling of vehicles,pp2901-2910 (1999).

3. **A. Nasri, A. Hazzab,I. K. Bousserhane and S. Hadjeri** "*Sliding Mode Propulsion System Control forTwo wheels Electric Vehicle Drive*" Journal of Electrical Engineering ,Vol 9, issue 1,(2009).

4. **K. Hartani M. B,o. urahlaand and B.Mazari** " *New driving wheels control of electric vehicle* ", Journal of Electrical Engineering ,Vol 5, issue 2,(2005).

5. **Brant D.D** "*Driving Cycle testing of electric vehicle batteries and system*" International Journal of Power sources, Vol 40,Issue 1,pp73-79 (1992).

6. **Ricardo Faria, Pedro Moura, Joaquim Delgado and Anibal T.de Almeida**, "*A sustainability assessment of electric vehicles as a personal mobility system"* Journal of Energy Conversion and Management, Volume 61, pp 19–30 (2012).

7. **Abbas Shiri and Abbas Shoulaie** "*End effect braking force reduction in high-speed single-sided linear induction machine*" Journal of Energy Conversion and Management, Volume 61, pp 43–50 (2012).

8. **D. Gewald,S. Karellas,A. Schuster and H. Spliethoff**, "*Integrated system approach for increase of engine combined cycle efficiency*" Journal of Energy Conversion and Management, Volume 60, pp 36–44 (2012).

9. **Rong-Chang Jou, Yu-Chiun Chiou and Ju-Ching Ke**, "*Impacts of impression changes on freeway driver intention to adopt electronic toll collection service* "Journal of Transportation Research , Part:c

Emerging Technologies, Volume 19, Issue 6, pp 945–956 (2011).

10. **Ruimin Li and Geoffrey Rose**," *Incorporating uncertainty into short-term travel time predictions*" Journal of Transportation Research , Part:c Emerging Technologies, Volume 19, Issue 6**,** December 2011, pp 1006–1018 (2011) .

11. **Nathaniel S. Pearre, Willett Kempton, Randall L. Guensler and Vetri V. Elango** "*Electric vehicles: How much range is required for a day's driving?*" Journal of Transportation Research, Part:c Emerging Technologies, Volume 19, Issue 6, pp 1171–1184 (2011).

12. **BOSE B.K** "*Power electronics and motor drives recent technology advances*" Proceedings of IEEE International symposium on industrial Technologies, pp 22-25(2002).

13. **F .Z. PENG, H. LI. G .J. SU and J.S.LAWLER**, "*A New ZVS Bi-Direction dc-dc Converter for Fuel Cell and Battery Applications*", IEEE Transactions on Power Electronics ,Vol .19, no .1 pp 54-65(2004).

14. **Y SASAKI, A OTOMO and F KAWAHATA**, "*Toyota braking system for hybrid vehicle with regenerative system*", The 14th international electric vehicle symposium and exposition, Orlando, USA, Paper No. SAKA_SBI, 1997.

15. **Tabbache, B. Kheloui, A and Benbouzid, M.E.H.** , "*An Adaptive Electric Differential for Electric Vehicles Motion Stabilization* ", IEEE Transactions on Vehicular Technology, 60 , Issue: 1,pp104 110 (2010).

16. **Jeongmin Kim., Sungkyunkwan, Chiman Park, Sungho Hwang,; Hori, Y. and Hyunsoo Kim** "*Control Algorithm for an Independent Motor-Drive Vehicle* ", IEEE Transactions on Vehicular Technology, Vol 59 , Issue: 7 pp 3213 - 3222 (2010).

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