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Grid Solar Hybrid Speed Controller for Electric Vehicle – A Working Model

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Abstract: ***This paper work presents a pulse width modulation (PWM) speed control technique for a working model of grid solar hybrid electric vehicle. The integrated system consist of solar panel, charge controller, battery, step down transformer, diode rectifier, PMDC motor, speed controller and PIC Microcontroller 16F876A. The working model can able to run on dual mode- solar and electricity. It can also be driven independently either by solar or electricity. The battery can be charge from solar panel (10W) or by power supply. The household single phase A.C. power supply of 230V is converted into 12V D.C. using step down transformer and rectifying circuit. The working model can achieve energy saving, low carbon emission, environmental protection for the upcoming future of human life. The motor speed is controlled by PWM technique implementation using the programming burn in microcontroller. This technique is implemented on working model and its application results in reduced current consumption and removal of mechanical parts. The experimental result shows that the digital controller is able to follow the reference speed and hence, speed control is achieved the result is shown graphically.***

Keyword: Hybrid electric vehicle, solar energy, Solar panel, PWM, PIC Microcontroller 16F876A, PMDC motor

1. Introduction

The whole world is moving towards the sources of energy which would never exhaust in future and do not harm environment. The environment is polluted mostly due to vehicles and rush of vehicles is increasing day by day and therefore fossil fuels are exhausted day by day. So, world is finding solution of this problem and in the pave with this they reached on electric vehicles. Electric vehicles are able to reduce pollution on tailpipe but at last pollution is increasing in power plants. To reduce the pollution at power plant also, world move towards renewable source of energy that is solar energy. Next challenge is that alone solar energy is not enough to drive the vehicle. So, at last world is now focusing on hybrid electric vehicles and trying to improve efficiency of hybrid electric vehicle. Here we are doing hybridization of solar energy with electricity.

The main objective of this paper is to study about hybrid electric vehicles and then design speed controller for hybrid electric vehicles. Here we are using PWM (pulse width modulation) technique for developing the speed controller of d.c motor for hybrid electric vehicles and at last we are implementing PWM technique by developing the hardware of working model and by studying the waveforms which is formed by working model. Eventually we are able to achieve our goals.

2. Literature Survey

In recent years, so many researches are going on for developing hybrid electric vehicles without using non-renewable sources of energy or with using renewable source of energy. But to save environment peoples are more emphasis on non- renewable sources of energy. Solar energy is the best non- renewable source of energy to use in hybrid electric vehicles. Many researches on hybrid electric vehicles with hybridization of solar energy with electricity have done. For optimizing hybrid electric vehicles and electric vehicles simulation software MATLAB (Matrix laboratory) [1] and VBB (virtual bread board) [5] has been most commonly used. The physically developed models for hybrid electric vehicles and electric vehicles are also been presented by many researchers [2] [3]. In order to analyse cost, size, performance and to obtain best feasible condition configuration for hybrid electric vehicles and electric vehicles.

3. System Configuration

The integrated system of working model consist of solar panel, charging system controller, PMDC motor, accelerator control, rectifier unit and batteries.

Fig. 1 is showing schematic diagram of the multisource solar/electric hybrid electric vehicle. Hybrid electric vehicle tends to use solar panel as a main energy source and plug in as an auxiliary energy source. Electrical energy is stored in battery and use to drive PMDC motor. PMDC motor is connected to the wheel of the motor. The IR sensor is connected near wheel of the hybrid electric vehicle which senses the speed of the electric vehicle and PWM is generated according to the speed of the motor and it controls the speed of the motor. The control on the motor (PMDC) is processed through the motor controller which give electronic commutation to the speed of the motor. The speed of the motor is derived using the electronic throttle (accelerator). Through the accelerator the current is reached in the H- bridge configuration and it apply the triggering pulses at the gate terminal of the MOSFETs (H- bridge configuration) controller circuit. When the battery get discharged (battery voltage is less than 11V) solar panel/ plug in starts charging the battery. Charge controller is used to select the mode of charging. When the solar energy is available is will charge the battery using solar panel and when solar energy is not available is will charged through plug in. Charge controller regulates the current from the main energy source and auxiliary energy source and fed the power into the battery.

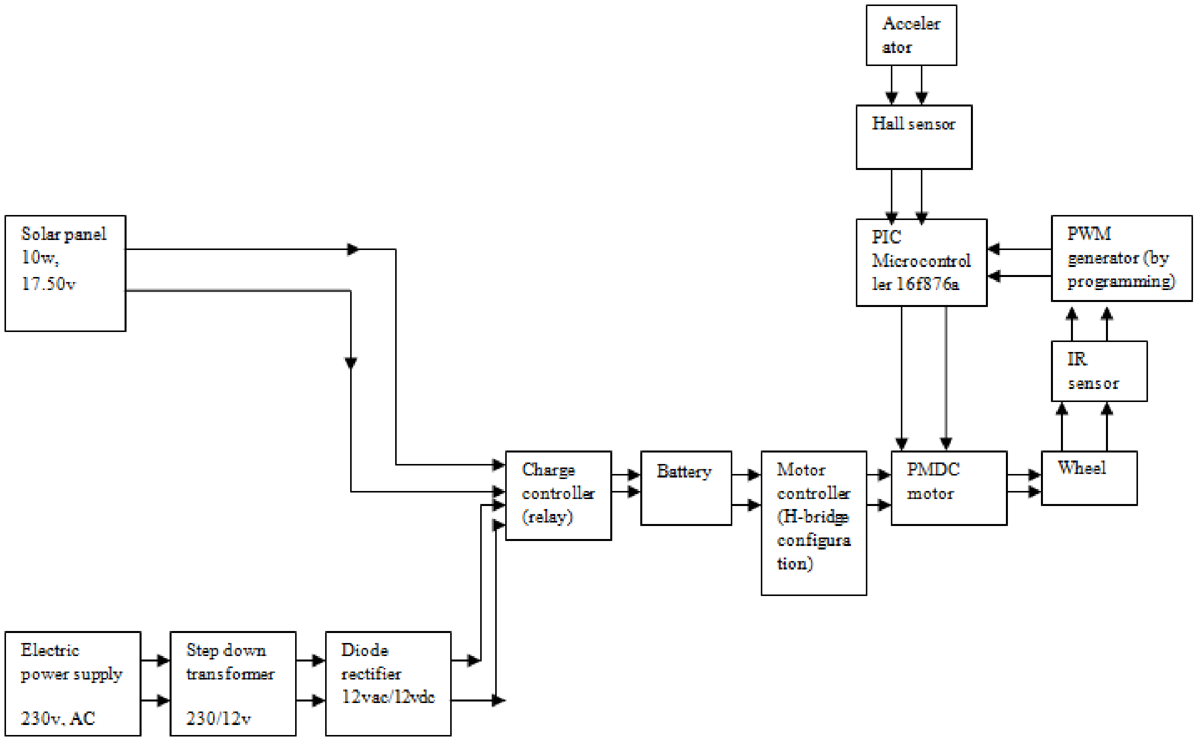

Figure 1: Overall Design of System Configuration

4. Hardware Implementation

The hardware implementation of proposed solar/electric hybrid vehicle's working model is shown in fig. 2, fig. 3 and fig. 4.

Figure 2: Hardware implementation of working model

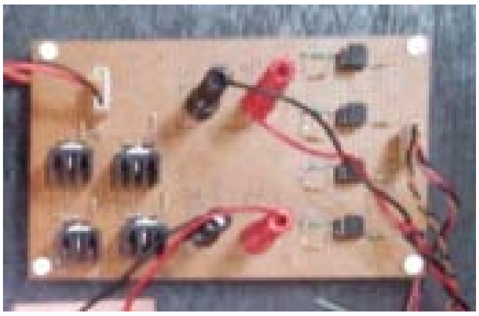

Figure 3: Connections of MOSFETs with battery and motor

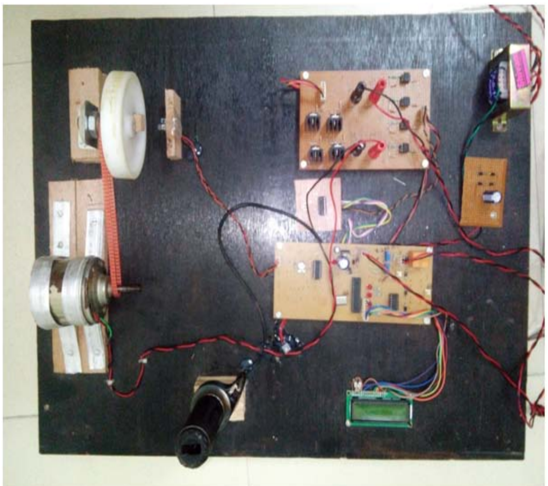

Figure 4: Close view of circuit connections of working model

In order to confirm the benefits of the proposed system, an experimental prototype for an hybrid electric vehicle is developed. As shown in figure, the solar panel with a rating of 10w is connected to the working model of hybrid electric vehicle. In the actual hybrid electric vehicle we can place solar panel on the top of the vehicle to seize the solar energy and then control it with charge controller. During sunless condition, the battery is charged from household supply of 230V by converting it into 12V with the help of step- down transformer and with the help of rectifier circuit 12V a.c. supply is converted into 12V d.c. supply to charge the battery. The battery is charged always from the solar panel and it provides power to drive the wheel of the working model. Four N-channels MOSFET are used in circuit to drive D.C. motor. The MOSFETs are connected in the H-bridge configuration to drive the D.C.

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motor. To derive the motor in forward direction two MOSFETs are connected in positive to negative direction and to derive the motor in reverse direction remaining two MOSFETs are connected in negative to positive direction. The PWM signals are generated using programming in c language and that programming is burn into microcontroller 16f876A. The advantage of using microcontroller 16F876A is that it is having inbuilt ADC (analog to digital converter), port A is completely ADC having a capacity of 10bit. The PWM modulation frequency is set to be 5 KHz. The crystal oscillator frequency installed in microcontroller having a value of 3.57MHz. ADC having a capacity of 10 bit means 210 bit equal to 1024. It divides the value into tenth part and its resolution is 5/1024 equal to 0.00482V (maximum voltage of microcontroller is 5V).

5. Test and Result

For the working model of hybrid electric vehicle, we are using permanent magnet direct current motor (PMDC) having 4 poles, 0.125 horse power at 12V and 50 Hz. During the test, working model is fed through a 220V rectified dc- power supply, with the help of batteries. The battery can also be charged from solar panel having a rating of 10W. During test wheel is rotated at its full speed having a cyclic RMS of 256.9mv and positive duty cycle of 23.1%. Controlled acceleration is achieved by pulse width modulation (PWM) technique with the help of IR sensor placed in front of wheel. The wheel is driven with the help of accelerator and waveforms have been recorded through cathode ray oscilloscope (C.R.O.). Fig. 5 showing the waveform when wheel is at rest means when we are not accelerating the working model of hybrid electric vehicle. This time positive duty cycle is 11.2% and cyclic RMS of 252.7mv. Fig. 6 is showing the waveform on CRO when wheel is rotating at full speed that time positive duty cycle is 23.1% and cyclic RMS is 256.9mv. This time however, control algorithm limit the motor's acceleration by imposing pulse width modulation. Therefore, the efficiency and battery life of grid solar hybrid electric vehicles can be improved by using the technique PWM (pulse width modulation) and by using solid state switches like MOSFETs having a capability of limiting current transients.

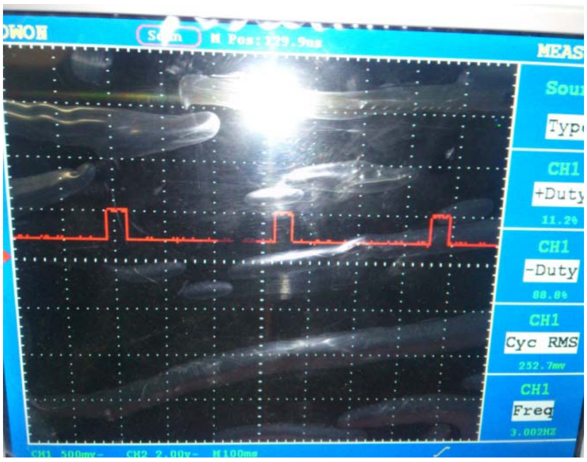

Figure 5: Waveform achieved at zero accelerator

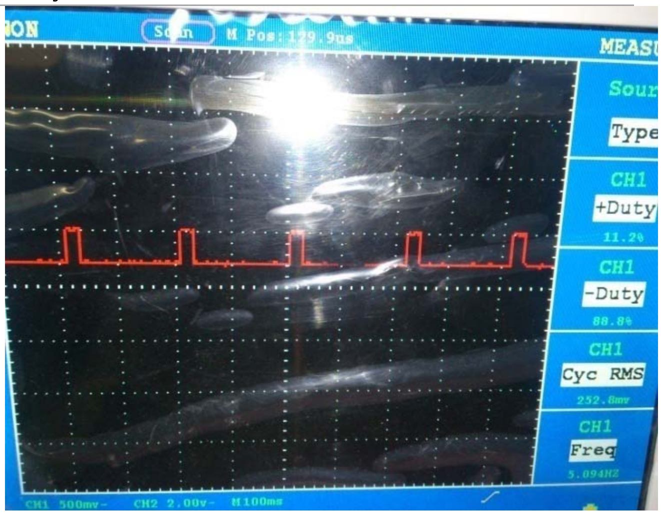

Figure 6: Waveform achieved at full accelerator

6. Conclusion

In this paper the working model for grid solar hybrid electric vehicle has been presented. The pulse width modulation speed control method is simple and inexpensive for D.C. motor control, implemented with a microcontroller 16F876A having an inbuilt analog to digital controller. This experimental result shows that hardware implementation of working model design prototype is suitable for actual designing of grid solar hybrid electric vehicle and this design is feasible and reliable for this kind of application. The aim of this project was to demonstrate that grid solar hybrid vehicle could be viable alternative to conventional vehicles and this could help to improve air quality in big cities, through the reduction in carbon dioxide emissions and by using renewable sources of energy (solar energy) we can reduce the world dependence on fossil fuel. The prototype realization is carried out successfully and the results have shown that the speed controller performs a stable and efficient motor control.

Future Scope

1. Battery technology: battery technology should improve so that vehicle runs more efficiently. Life of battery should increase so that more consumers attract towards the hybrid vehicles with keep in mind that battery does not harm the environment.
2. Simulation software and testing equipment: simulation software like MATLAB and VBB are present to simulate electric vehicles but they are not giving exact result. For this improved simulation software will be design and testing equipment could also be design.
3. Renewable fuels: hybrid electric vehicles running on electricity that is not emitting pollution on the tail pipe but at the time of generation of electricity it is emitting pollution at the power stations and at last polluting the environment. So, for this renewable fuels like biodiesel and ethanol should be use.
4. Solar panels: solar panels designing should be improved making it more efficient. Reflecting mirror can be used for absorbing more sunlight so that more electricity will be generate and PV tracking system

could be used for trapping more energy from sunlight and making vehicle more efficient.

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