Hybrid Electric Vehicle with Solar Charging Assist

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Abstract - *The hybrid electric vehicle (HEV) essentially uses two power sources to power the vehicle. At present, one power source is the internal combustion (IC) engine (gasoline or diesel fueled) and the other is chemical batteries combined with an electric motor drive. In addition to these systems, we aim to incorporate solar charging assistance, for charging the battery module that powers the electric motor drive as well as regenerative braking. When certain criteria such as absence of the solar energy source coupled with a complete drain of the battery occurs, the internal combustion engine kicks in and the vehicle works just like a normal automobile. By adopting this approach, we can optimize both the operating life of the vehicle as well as reduce the emissions, thereby offering a much greener alternative to conventional automobiles.*

***Key Words*: Hybrid Electric Vehicle, IC Engine, Chemical batteries, Regenerative braking.**

1. INTRODUCTION

Owing to the rapid increase in pollution levels, there is a need to explore new ways to power our homes, vehicles, and businesses. This need has increased dramatically over the recent years owing to the fear of fossil fuels running out and its resultant social and environmental effects. The depletion of crude oil reserves has occurred at a rapid rate due to the increase in fuel consumption by our automobile industry.

The focus has now fallen on electric vehicles owing to their reduced emission levels. A major limitation of electric vehicles is that, it is an extra load on the electric grid and since many countries face an energy deficit, it is not currently feasible to use electric vehicles. Pure electric vehicles, though are not fully free of emissions. If the batteries are charged using energy generated from fossil fuels, polluting gases are still formed at the power plant. Hence they can only reduce and decentralize the pollution and cannot eradicate it completely. An alternative source of power that is being developed is the use of solar power to run automobiles. A hybrid vehicle makes use of two or more distinct power sources to power it. Hybrid Electric Vehicles (HEVs) combine both solar and electrical energy. The hybrid electric vehicle is driven by an AC universal type electric motor, whose performance is governed by a motor controller (variable voltage accelerator), which further gets its power from a battery, that can be charged through a battery charger.[6] Also solar charging assist has been incorporated, which charges the battery to its safe limit and then disconnects itself in-order to prevent overcharging. This provides an additional layer of safety and security to the vehicle. In a conventional braking system, kinetic energy is lost as heat energy in air stream while braking via mechanical friction brakes. Thus, a lot of energy is wasted every time we apply the brakes. Regenerative braking is a process wherein this kinetic energy is stored in a short term storage system such as battery and utilized later for accelerating the vehicle.[2]

Conventional electric vehicles have a single charge range significantly lower than the motor car, making it unpopular with the masses. However, by the use of technology such as solar powering of hybrids and regenerative braking, the limitations of conventional electric vehicle can be diminished to an extent where its practical use is a current possibility and not a future prospect.[4] HEVs thus successfully combine the conventional ICE driven mechanical drive train with a motor propelled electric drive train. A hybrid electric vehicle produces less emissions from its ICE than a comparably sized conventional car. An HEV's gasoline engine is usually smaller than its comparably sized conventional counterpart and if not used to directly drive the car, it can be geared to run at maximum efficiency, further improving on fuel economy.

1.1 System Model

The model of hybrid electric vehicle is shown in fig1.

Fig – 1: Hardware setup of Hybrid Electric Vehicle

The vehicle is powered by a Solar panel of 120W, OCV 18.6V. A 12V, 80Ah battery was used for the vehicle. MPPT module was implemented on a printed circuit board, to maximize the power output from PV panel. An MPPT charge controller of 20A, 12V rating is used. The electric motor drive consists of a universal motor rated for 750W, 1500rpm. Voltage controlled acceleration is provided for controlling the acceleration of the electric drive train. A DC generator which gives an output of 12V, 30A is used for regenerative braking.

The HEV is started on electric motor drive. When the battery voltage falls below 10.5V (ie: the battery is discharged), the HEV switches to IC engine drive. Once the HEV is running, in-order to avoid damage to the starting system, a relay circuit is used to turn off the starter motor. Regenerative braking is achieved by means of DC generator attached to the wheel of the HEV.

1.2 Block Diagram of Hybrid Electric Vehicle

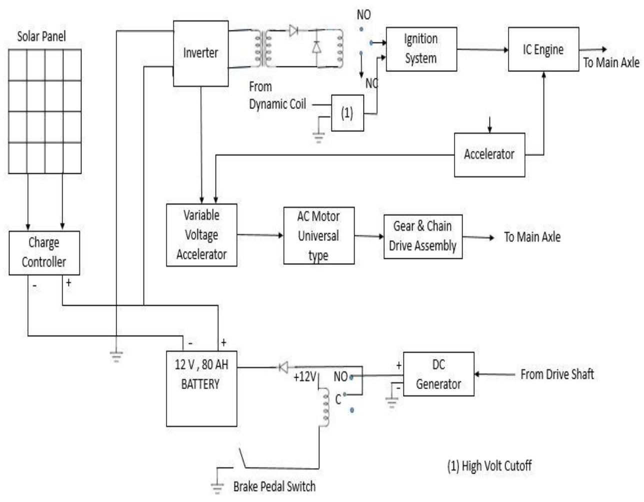

Fig-2: Block Diagram of Hybrid Electric Vehicle

A solar panel is connected to the MPPT charge controller unit, through which the battery (12V, 80Ah) gets charged. The inverter circuit powers the universal motor, by converting the available DC supply to AC. The inverter output will be high and the relay coil gets energised. However, the AC universal motor runs at a higher rpm, this cannot be directly applied to the wheels as torque at such high rpm will be low and the vehicle will not run properly. The rpm is reduced to a suitable value by means of a reduction gear. This improves the available torque.

When the battery is discharged, the inverter output falls to low value and the coil de-energises. As a result the relay switches and ignition system gets the positive voltage. The negative voltage to starting coil is obtained from a comparator circuit. The input to the comparator circuit is given from the dynamic coil of the IC engine. The reference is kept at ground potential. The ignition system starts the IC engine when its inputs are obtained.

2. WORKING

In normal operating mode, the vehicle is designed to run on the electric motor drive. The electric drive consists of a 12V, 80Ah battery and an inverter circuit. The motor used is a universal type AC motor. The battery output is supplied to the inverter, which supplies AC output that can be used to power the electric motor drive. In order to vary the motor acceleration, the inverter output is regulated by a voltage varying circuit. When the battery voltage reaches below 10.5V, automatic switchover to IC engine takes place. The inverter circuit has a battery level indicator, which monitors the battery voltage level. The voltage level indicator output is given to a 3 pole relay. The relay is used to switch the ignition coil, when the pre-requisite condition is met. The negative terminal of the ignition coil is given through an electronic circuit consisting of a comparator. The HEV changes over to the IC engine drive with the help of a relay circuit. Once the HEV starts running, voltage builds up in the dynamo coil. When this voltage goes above a set reference voltage, the output of the comparator circuit goes high. The electronic switch opens which in turn releases the starter motor and prevents damage to it. In a conventional braking system, kinetic energy is lost as heat energy in airstream while braking via mechanical friction brakes. Thus, a lot of energy is wasted every time we apply the brakes. Regenerative braking is achieved by the use of a high current dc generator which is attached to the wheel of the HEV. The braking is carried out in two levels. When we pressurize the brake pedal to the first level, it activates a switch connected to a relay terminal. The common terminal of the relay is connected to the battery and the NC terminal is connected to the DC generator. On applying the brakes, the battery and DC generator gets connected. When this connection occurs, the DC generator gets loaded which results in a braking action. If this braking action is found to be insufficient to arrest the motion of the vehicle, the second level of braking can be used. Here, the conventional mechanical brakes are applied. In order to prevent the reverse flow of current a protective diode is connected. Solar charging assist is provided for the battery. The solar panel is connected to the battery through a charge controller unit. When PV output is less than load demand, the battery feeds the load. When PV output is same as the load demand, the battery gets charged. It is critical to prevent overcharging and deep discharging of batteries to preserve its life. This is achieved by the MPPT charge controller unit.

2.1 Observations and Result

The vehicle was tested and validated using digital oscilloscope and multimeter.

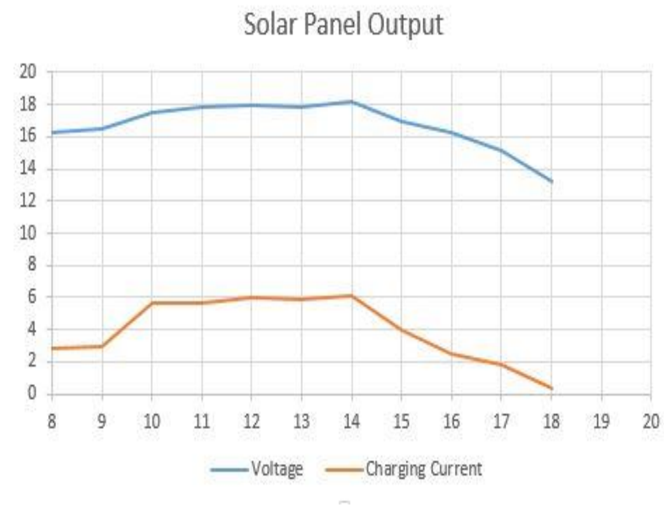

Fig-3: Solar Panel Output measured during different hours of a day

Fig - 3 shows the charging current and voltage of the solar panel measured during different hours of a day. It is seen that the maximum output voltage is available during the interval of 10am to 3pm.

The switching of modes of operation and the power flow in each mode was tested and validated for vehicle by varying battery voltage and observing current flow using multimeter. Fig - 4 shows the filtered output of the inverter.

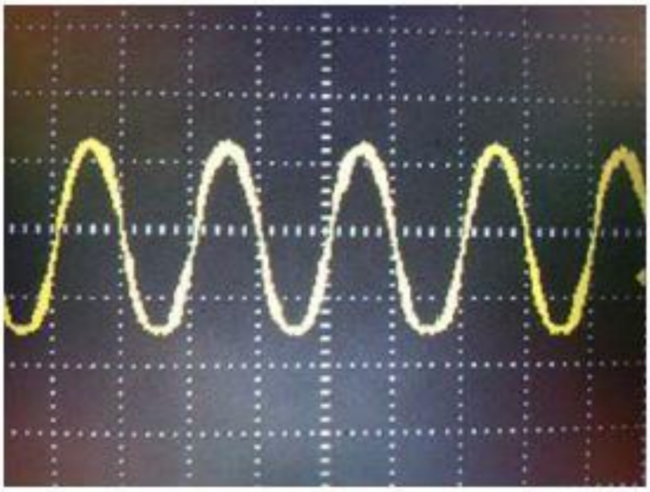

Fig-4: Filtered Output of the Inverter (10V/div)

The power vs time graph for the PV Panel using MPPT technique is shown in Fig - 5. Vehicle battery was charged in a standalone mode using solar panel. Battery reaches full charge from 50 % charge in 4 hours. This validates the principle of operation of solar powered hybrid electric vehicle.

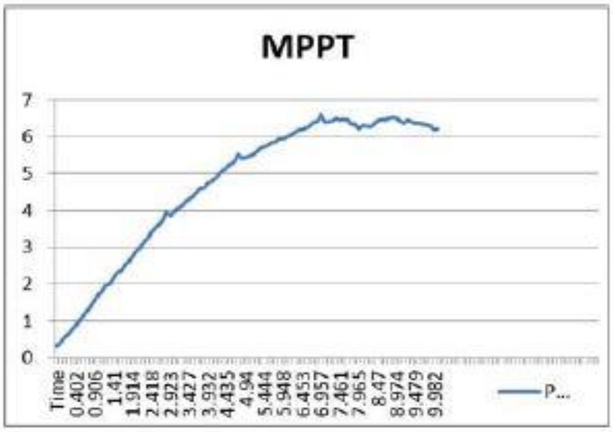

Fig-5: Power vs Time Output of MPPT under test conditions

Fig-6 shows the output voltage generated by regenerative braking system measured for various speeds. Voltage produced remains almost constant for a speed range between 10 km/hr 20 km/hr.

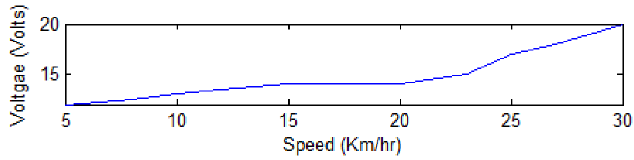

Fig-6: Output voltage generated by regenerative braking system measured for various speeds

2.2 Advantages of Hybrid Electric Vehicle

1. Environmentally friendly: One of the biggest advantage of hybrid electric cars over gasoline powered car is that it runs cleaner and has better gas mileage which makes it environmentally friendly.

2. Financial benefits: Hybrid electric cars are supported by many credits and incentives that help to make them affordable. Lower annual tax bills and exemption from congestion charges comes in the form of less amount of money spent on the fuel.

3. Regenerative braking system: Each time you apply brake while driving a hybrid electric vehicle helps you to recharge your battery a little. An internal mechanism kicks in that captures the energy released and uses it to charge the battery which in turn eliminates the amount of time and need for stopping to recharge the battery periodically.

2.3 Limitations of Hybrid Electric Vehicle

1. Less Power: Hybrids are twin powered engine. The gasoline engine which is primary source of power is much smaller as compared to what you get in single engine powered car and electric motor is low power. The combined power of both is often less than that of gas powered engine.

It is therefore suited for city driving and not for speed and acceleration.

2. Poor Handling: A hybrid electric car houses a lighter electric engine and a pack of powerful batteries. This adds weight and eats up the extra space in the car. Extra weight results in fuel inefficiency and manufacturers cut down weight which has resulted in motor and battery downsizing and less support in the suspension and body.

3. Higher Maintenance Costs: The presence of dual engine, continuous improvement in technology, and higher maintenance cost can make it difficult for mechanics to repair the vehicle. It is also difficult to find a mechanic with such an expertise.

3. CONCLUSION

The Hybrid Electric Vehicle combining both solar charging and regenerative braking technology is built and tested to provide a pollution free alternative to Internal Combustion (IC) engine drive vehicles. A MPPT charge controller unit was used to charge one 12V, 80Ah battery making use of a 120W, 18.6V solar panel. Regenerative braking using DC generator is employed and can certainly be used to provide regenerative power to the auxiliary equipment connected in the vehicle. However the major limitation of the system is its high initial cost. Further improvement in battery charge measurement technique and faster charging techniques will make it more efficient and feasible. Solar powered electric vehicles are the way forward for a greener tomorrow.

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