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Dynamic Programming Based Optimised Energy Management Strategy

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ABSTRACT

A bidirectional dc/dc on-board charger for EV battery discharging/charging application is a preferable choice for V2G and G2V compatibility. It is useful for EV applications since isolated converters favour working with high power densities over a variety of loads. The bidirectional converter performs the stepup and stepdown operation at zero voltage switching for all power switches in both directions. EVs can be connected to the grid using either direct or indirect architectures, which are two different forms of architecture. Under the direct architecture, there is just one communication channel available for use by the EV and the grid system operator. The older design is the main topic of this essay. When electric vehicles (EVs) connect to the grid to provide various V2G services, they participate in continual charge-discharge cycles. These cycles may be of great concern to the owners of the vehicles because the cost associated with the degeneration of the EV batteries needs to be investigated and analysed. The strategy based on reinforced learning will be able to present a solution which is close to the optimal solution achieved by suing dynamic programming.

Keywords: *Energy Management; Dynamic Programming; Simulation; Discrete Transition; Optimal Power Split.*

1.0 Introduction

Due to their increased fuel efficiency, plug-in hybrid electric vehicles (PHEVs) now make up a rising portion of the global vehicle industry combine the advantages of conventional and electric vehicles (EVs) HEVs are hybrid electric cars that use less fossil fuel emissions. PHEVs (plug-in hybrid electric cars) are an example of the as a result of superior fuel efficiency, environmental benefits and ability for all-electric drive[1].They're motivated two principal sources of power: one or more electric motors and fuel cells against internal combustion engines (ICEs) in comparison to PHEVs and other hybrid electric vehicles (HEVs) are outfitted. This can power the car with a greater energy storage system. The management of this power split has a significant impact on how well a parallel HEV system performs. Heuristic control techniques that are based on straightforward rules or maps appear to be lagging behind controllers that are based on minimising fuel consumption. The ideal power management can be expressed as a nonlinear finite-horizon optimum control problem.[2]

Dynamic programming (DP) is one of the most widely used solutions to the control problem mentioned above among the many described ways. Its mathematical underpinnings are simple, it assures the optimality of the solution chosen for a specified tolerance, and it might be simply

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implemented in a short computer programme. The two types of energy management procedures that are most frequently employed in the creation of supervisory controls are instantaneous optimization and finite-horizon optimization . Instantaneous based on approaches, power flow is provided for real-time applications.

Optimal theories are also strong contenders for controlling how HEVs and PHEVs distribute their energy[3-4]. Dynamic programming (DP) can identify the best way to cut fuel usage in a HEV or PHEV given the trip data. However, DP's online applicability is constrained by its lengthy computation time. To somewhat reduce calculation time, a two-scale DP method was used. In order to improve energy management, this method divides the entire trip into a number of parts and applies DP twice throughout the entire trip and throughout each segment[5]. The energy management of PHEV was handled using the quadratic programming (QP) approach. This technique, which represents engine fuel rate as a series of quadratic equations with respect to battery currents at various driveline powers and vehicle speeds, requires other sophisticated techniques to ascertain engine-on power.

2.0 Energy Management Strategies

For controlling the power an energy management technique is used and this must be able to fullfill the demands required by the drive profile [6]. The power is divided into two viz ICE and EM and the strategies are illustrated as –

2.1 Rule-based control strategy

The different criterion the vehicle model are maintained while putting focus on optimizing fuel economy by formulating the problem of expected energy cost [7]-

$$J_{xt}(SOC(t) = \int_{t}^{t_f} m(t,u)dt \qquad \ldots(4)$$

Where Jxt (SOC(t)) – cost function . the starting position xt to the final position is limited in this constraint for the time period tf[8].

2.2 MPC strategy for the route

The problem formulation and it solution is run online in a repetitive scenario by considering the rolling horizon and is expressed as[9]-

$$SOC(i+1) = f(SOC, u(i)) \qquad \ldots(5)$$

Where $SOC(i + 1)$ –estimated state of charge

2.3 Optimization methods

The problem formulation for the n number of steps is as shown below-

$$J_{tot}(k) = J_p(k) + \alpha \sum_{j=0}^{N} \left\| f(k) - fopt.(k^1) \right\|^2 \qquad \ldots(7)$$

The process will get the optimal vector and then the progressive computation has been performed with the help of MPC[9]. There is no use of convex optimization because it will then make it compulsory to select feasible technology.

2.4 Performance measures

$$M_{abs} = \frac{1}{k} \sum_{t} \left[\frac{|y(t) - y'(t)|}{y(t)} \right] \qquad \ldots(8)$$

$$R_{rel} = \sqrt{\frac{1}{\sum_t y(t)} \sum_t \left[\frac{|y(t) - y'(t)|}{y(t)} \right]^2 y(t)} \quad \ldots(9)$$

The strategy is evaluated in terms of real and predicted values which makes the performance indices and this comparison is done on different levels of time [10]

3.0 Model Description

The parallel hybrid electric vehicle model is taken and the parameters are illustrated in the below given table-

Table1: Vehicle Parameters Used for Simulation

Vehicle weight	15000 Kg
Motor ratings(power)	43 KW
Torque	200 nm
Engine ratings	120 hp
Battery pack	VRLA
Battery capacity	110 Ah
Terminal voltage	145 V

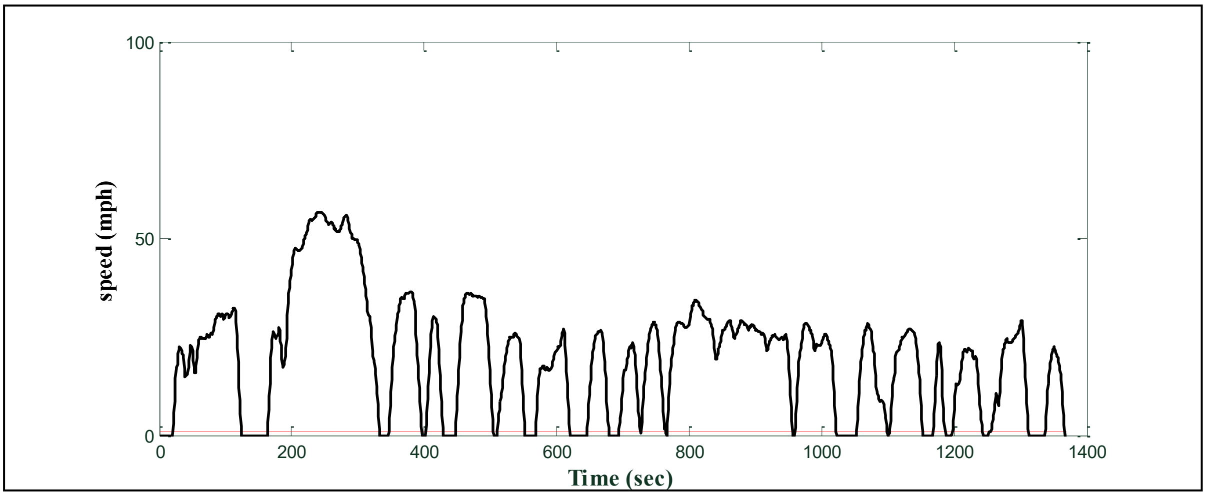
3.1 Driving cycle

In order to make the study more reasonable, the different five types of drive cycles are taken here which are shown graphically in the figures. These cycles are taken in the repetitive sequence so that the total simulation time can be long enough to test system properly and the differences can be observed significantly [12].

4.0 Results

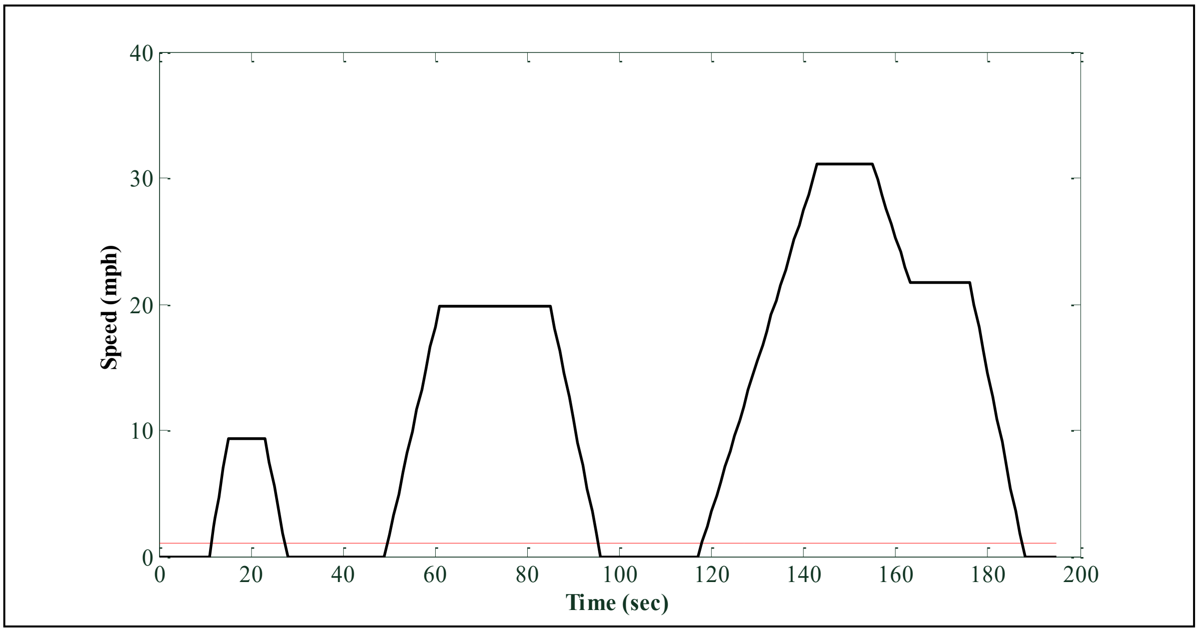
The velocity profile of the four velocity profiles i.e. UDDS, ECE, are specified in the following below figures – fig.1 and fig.2 respectively.

Figure 1: UDDS Drive Cycle



In order to make the study more reasonable, the different five types of drive cycles are taken here which are shown graphically in the figures. These cycles are taken in the repetitive sequence so that the total simulation time can be long enough to test system properly and the differences can be observed significantly.

Figure 2: ECE Drive Cycle



5.0 Conclusion

When electric vehicles (EVs) connect to the grid to provide various V2G services, they participate in continual charge-discharge cycles. These cycles may be of great concern to the owners of the vehicles because the cost associated with the degeneration of the EV batteries needs to be investigated and analysed. As a result, when discussing the battery's degradation, the battery cycle life (CL) must be taken into consideration. In this work, the state of charge parameter is employed to evaluate the results of sequential simulation for various drive cycles.

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