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Plug-in Hybrid Electric Vehicle

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Background

➢Plug-in Hybrid Electric Vehicles (PHEV) are the new generation Hybrid Electric Vehicles (HEV). They eliminate the shortcomings of both Conventional Vehicle and Electric Vehicles and combine both in one vehicle. These vehicles can be charged overnight through the household power supply.

➢Plug-in Hybrid Electric Vehicles can be used for daily driving of about 40 miles by using primarily battery power. But if the vehicle travels further beyond 40 miles, it would then work as an Hybrid Electric Vehicle.

Objectives

➢Improve current Plug-in Hybrid Electric Vehicle (PHEV) concept by designing and implementing more efficient energy management strategies.

➢Reach a fuel economy of 100 miles per gallon of gasoline for a 40 mile range.

➢Modify a 2008 Toyota Prius to a Plug-in Hybrid Electric Vehicle.

Fig 1: Toyota Prius converted into PHEV

Plug-in Hybrid Electric Vehicle:

➢Two Toyota Prius (2008) have been converted to Plug-in HEV.

➢The 5 Kwh Li-Ion battery pack is added to the Prius for plug-in operation.

➢This extra battery pack works along with the original Prius 1.2 Kwh NiMH battery which is charged from the household power supply. The Li-Ion battery pack is targeted for Regenerative Braking and Engine Charging in this research.

Fig 2: 5 Kwh Li-Ion battery installed.

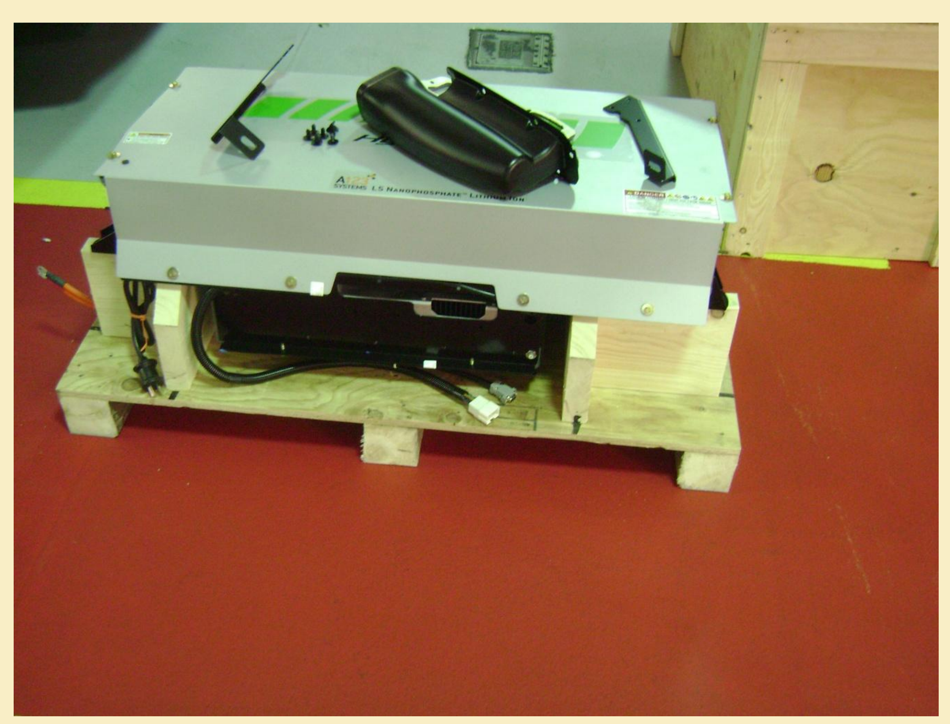

Fig 3: Li-Ion battery pack.

Modeling and Simulation Results:

➢The modeling of the Prius Hybrid Electric Vehicle is done using the ADVISOR software. The existing model for the Prius Hybrid Electric Vehicle is modified to obtain the Plug-in Hybrid Electric Vehicle.

➢A Rule-Based Strategy (RBS) is developed for Energy Management and it is implemented in the simulation model for the plug-in HEV.

➢This rule-based strategy is then compared with the existing strategy used for the Prius Model in the ADVISOR software.

➢The results obtained show significant increase in the gas mileage from 74.8 MPG for Prius Model strategy to the 87.6 MPG for the proposed rule-based strategy for a driving distance of 37.2 Miles.

➢Engine efficiency also increased from 29% to 35 % for the proposed RBS strategy.

➢This rule-based strategy is being further improved where the Particle Swarm Optimization method is utilized to optimize the PHEV energy management system.

➢The objective function of the optimal energy management system is selected as follows:

$$Min:\ Fuel\ Used(x)$$

➢This PHEV system is subjected to the following constraints:

$$\tau_{ENG} = \tau_{REQ} - \tau_{MOT}$$

$$\omega_{ENG} + \omega_{GEN} = \omega_{REQ}$$

$$0 \le \omega_{ENG} \le \omega_{ENG\ MAX}$$

$$0 \le \tau_{ENG} \le \tau_{ENG\ MAX}(SOC)$$

$$0 \le \tau_{MOT}(\omega_{MOT}, SOC) \le \tau_{MOT\ MAX}(\omega_{MOT}, SOC)$$

$$SOC_{MIN} \le SOC \le SOC_{MAX}$$

$$\omega_{GEN\ MIN}(SOC) \le \omega_{GEN} \le \omega_{GEN\ MAX}(SOC)$$

➢This optimizaton problem is currently being investigated using the Particle Swarm Optimization Technique.

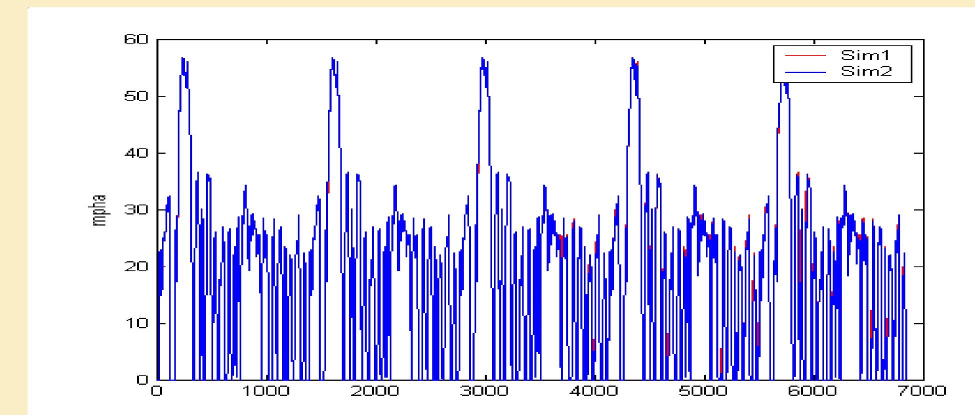

Fig 4: EPA drive cycle for Both

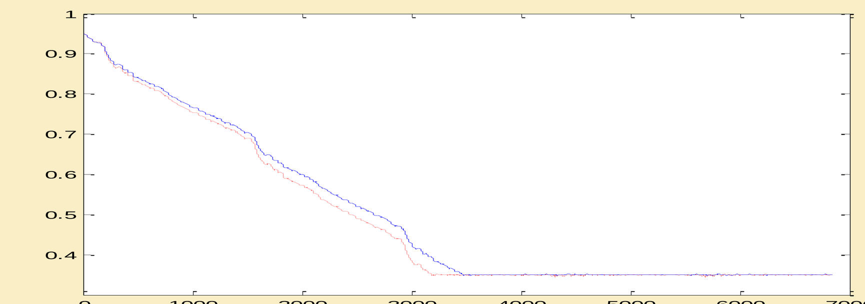

Fig 5: SOC of prius strategy (blue) and SOC of RBS (Red)

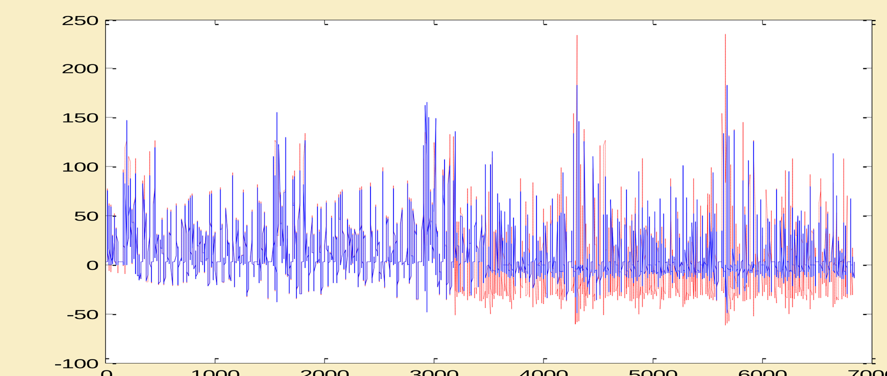

Fig 6: Current drawn from prius battery (blue) and current drawn from RBS (RED)

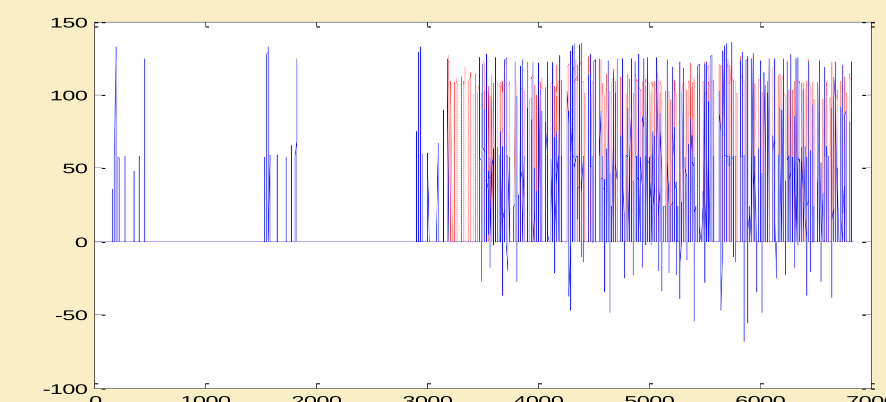

Fig 7: Engine Torque for prius strategy (Blue) and Engine Torque for RBS (Red)

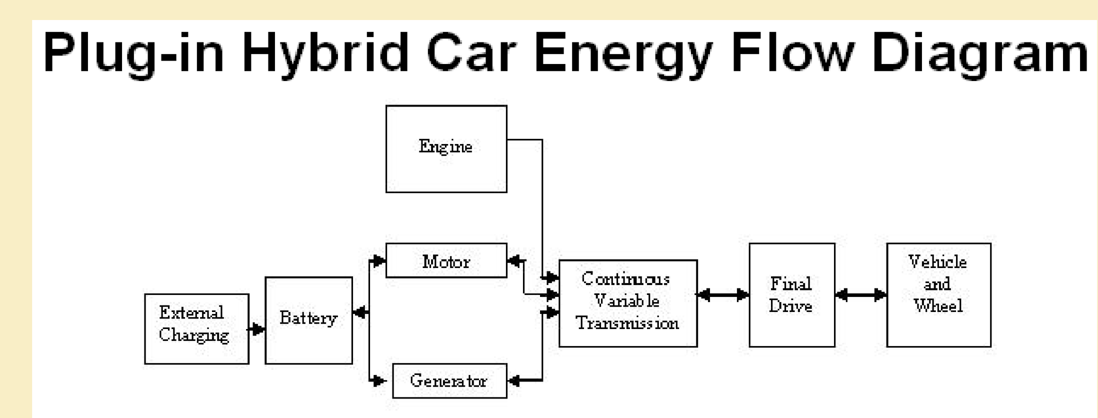

Fig 8: PHEV energy flow diagram.