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Capacity fade and aging models for electric batteries and optimal charging strategy for electric vehicles

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Abstract— Due to the increasing concern for energy efficient storage devices, extensive research is being done on the mechanisms which are involved in the battery degradation process. Optimality in electric vehicle energy management has been traditionally pursued from the perspective of efficient grid operation, but barely considering battery degradation in the process. The objective is to formulate a battery degradation model which will yield the degradation suffered by a battery as a function of its use, allowing both the comparison between different energy management strategies as well as including the model in linear optimization algorithms.

Nearly three-hundred tests were carried out on Li-ion battery cells which were subjected to different depth-of discharges, currents and temperatures. Results are used to identify the variables which categorize best, using self-organizing maps, the degradation suffered by the cells. A model is proposed which yields the rate of degradation of the battery as a function of both temperature and depth-of-discharge. This model is then linearized and used in an electric vehicle energy management optimization problem, where the degradation suffered by the battery due to a controlled charge is minimized. Finally, the results are compared with other charging methods.

Index Terms— Battery degradation models; Capacity fade; Self-organizing maps; Electric vehicles; Energy management

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