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OPTIMAL CONTROL OF HYBRID POWER SYSTEMS

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Abstract. We develope a mathematical model for the operation of a hybrid power system consisting of a renewable energy source, a battery bank, an inverter and a generator. The aim is to operate the system in an efficient manner whilst satisfying a given load demand. The model results in a discrete valued optimal control problem which can be solved using a recently developed transformation technique. Numerical results are presented and discussed.
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1 Introduction

Hybrid power systems are commonly used to supply electricity in remote locations which cannot be practically supplied by a main power grid. Such a system typically consists of a renewable energy source (wind turbine or photovoltaic (PV) array), a battery bank for storage, an inverter, and a diesel generator (see [1], [2], [8], and [12]). Any one such system may contain a number of these individual components. The task of minimizing the overall cost of such a system involves an appropriate choice of the individual components (in terms of their capacity) whilst satisfying various performance requirements demanded from the system. At the operational level, given an existing hybrid power system, one would like to control the day to day operation of this system to minimize the running cost whilst satisfying load demands on the system.

In this work, we consider the problem of controlling a given hybrid power system in an optimal manner so that the overall operational cost is minimized while load requirements and various constraints are satisfied. In particular, we are interested in determining the optimum running times and levels of operation of the diesel generator(s) over a fixed time period. We assume that the given generator(s) can operate at a number of different levels of power output. Alternatively, as generators operate most efficiently at full capacity [8], a system may have multiple generators of different capacities and each of these can be either switched off or run at full capacity. In this way, the case of running multiple generators also results in a number of different levels of power output, although the cost of operating the generators needs to be calculated in a somewhat different manner. In either case, we need to choose the switching times between the various power output levels to optimize the overall system performance. Furthermore, the objective functional of the proposed model also contains a term which takes into account the additional mechanical wear on the generator(s) due to short periods of operating in a particular mode. A third consideration in the objective functional is the cost which can be attributed to the discharge/recharge cycles of the battery bank. Deep cycles can significantly shorten the usable life time of the battery bank [2]. A first attempt to include this cost in the model is presented here, although we envisage that this aspect of the model will be refined further in future work.