**Greedy-based RBS maximum allowable current calculation method**

**基于贪心策略的可重构电池系统最大允许电流估计**

**静态的**

**Abstract**

**Keywords**

**1. Introduction**

【储能电池系统的重要性】

Battery energy storage systems(BESS) 被用在新能源汽车、风力发电站等场景中，为设备提供高品位电能的保存和释放。

Battery energy storage systems (BESSs) are used to store and release timely high-grade electrical energy in scenarios such as electric vehicles and wind power plants. A large number of individual battery cells are connected in groups by circuitry to form the main body of BESSs and achieve the required capacity and voltage for the application. However, the large number also poses a challenge to the reliability of BESS: the system’s capacity and life mainly depends on the least healthy battery cells, known as cask effect. Since BESS’s multiple charge/discharge cycles exacerbate the inconsistency of individual cells, the unhealth batteries will appear early in operation.

【RBS的先进性、现状】

Reconfigurable battery system(RBS) 解决固定电路电池组的 cask effect：系统的容量和寿命取决于状态最差的某些电池。

此外，不一致性也在系统运行中加剧恶化。

通过动态改变电路，调控或隔离不良电池，有助于提升系统整体可靠性。

但是，重构也增加了设计、分析和控制的难度。

当前，系统有成百上千的电池，平均每个电池由3~5个开关控制，形成了庞大的状态空间。

Reconfigurable battery system (RBS), which can dynamically change the connections between batteries and switch between different circuit configurations as required, is expected to solve the above problem. Different from fixed configuration, reconfigurable circuits have additional switches connected with battery cells in specific topological patterns. The switching of series/parallel relationships and even the isolation of unhealth batteries can be achieved by controlling the states of these switches (open or closed). From the point of view of the battery cells, RBS has a higher reliability than conventional configurable battery system. But the difficulty of design and control are simultaneously increased. Each battery is controlled by 3 to 5 switches on average in RBS. When the system has hundreds or thousands of cells, a huge state space waits to be solved.

The importance of maximum allowable current (MAC) is gradually being noted as people research RBSs, defined as the maximum current that the system can output to external electrical equipment when the currents of all batteries in the system do not exceed the specified value. From the definition, it can be understood that MAC determines the maximum output current of the RBS during normal operation at the design stage, and of the reconfigured system when the failed batteries are isolated in the running-in phase. MAC is therefore one of the important indicators used in the study to design and evaluate RBSs.

(#TODO: 一些考虑最大许用电流的构建结构的策略)

But no existing literature about RBSs provides a method for calculating MAC.

【快速评估系统最大电流的作用和意义、文献现状】

（一些典型结构、控制策略、评估）

快速评估系统最大允许电流在设计、分析和控制中起到重要作用。

对设计，系统的最大输出电流

对控制，应对故障，静态结构破坏

但是没有严谨研究最大电流。（直接说没有）

~~一些研究使用了过度的简化，不准；（具体文献？）~~

~~只针对小数量的电池和特定的结构，不普适（具体文献，容易找到）~~

【本文的主要内容和结构】

我们提出了快速估计RBS的算法，基于贪婪策略。填补了这一空白。

The purpose of this paper is to propose an effective and efficient algorithm based on the greedy search strategy to solved RBSs’ MAC. A mathematical model of MAC is constructed and the optimal solution is searched in the state space of switches using maximizing the number of cells directly connected in parallel as the strategy.

This paper is organized as follows. Section II presents the mathematical model and the algorithm in detail. Section III solves an example proposed by XX(#TODO) and discusses the results. In the end, Secti\seon IV provides concluding remarks and directions of future work.

文章组织：section 2，算法的框架和细节；section 3，案例，讨论和验证；section 4 总结。

**2. Method**

2.1 模型搭建

【电路，有向图，规定，假设】

node，连接battery和switch，编号顺序

edge，battery 或 switch，编号顺序

电池等效为恒压ub串内阻rb

Ro，外电阻

关联矩阵

x，开关状态，01变量

【模型，求解方法】

假设均一化，矩阵分块

在导纳矩阵非奇异的条件下

推导出输出电流Io和电池电流Ib

用外电流Ib比所有电池中最大电流max（Ib）之比，表征电路的最大许用输出。是电路结构本身的性质，与电池无关。电路的线性保证了。

目标问题转化为【数学形式】

Max rate

s.t.

2.2 模型求解

使用贪心算法策略求解

【贪心策略】

电池i的最短路径，短指的是路径上电池数量最少

贪心策略，当系统中越多的电池被以最短路径联入电路，外电路电流越大。

【总体流程（二分查找）】

对于给定结构和最大许用电流通过如下步骤得到：

（伪代码开始）

通过图查找，深度优先，对每个电池找最短路径

以二分策略选择考察电池数量N\_{select}

通过组合，形成C^{N\_select}\_{N\_total}种方式，对于每种方式

仅将选中的电池最短路径上的开关状态设置为1

求解电流，公式

检查各电池电流，是否短路或超过电池的最大许用电流（否，break）

给出外电路电流和所有电池电流的最大值，计算比率

（伪代码结束）

电池电流Ib不超过ub/rb，未短路，合法（电池电流Ib受外电路Ro影响，考虑设一个固定值Ibmax，表示电池最大许用电流）

**3. An example and discussions**

经典结构

建模

结果正确性研究

计算效率验证（解方程法，经典方法）

**4. Conclusion**