Hybrid Energy Storage System for Powered Wheelchairs

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Introduction

Drawbacks of Batteries on Powered Wheelchairs (PWC)

- limited range, long recharge time, frequent replacement

Potential Solution

- Hybrid energy storage systems (HESS) consisting of supercapacitor and battery (complimentary benefits of both seen in Table 1)

Table 1: Comparison of battery and supercapacitor characteristics

Battery	Supercapacitor
High energy density (30-40 Wh/kg)[2]	Low energy density (2-30 Wh/kg)[2]
800-2000 recharge cycles[2]	~1 million recharge cycles[2]
Low power density (0.18 kW/kg)[2]	High power density (4-10 kW/kg)[2]

Project Scope: modeled HESS consisting of supercapacitor, battery, and recharging generator to investigate ability to extend battery lifetime and range for PWC

Methods

- Three systems modeled in Simulink (described in Table 2) and subjected to same power load (see Figure 1[8])
- Rule-based strategy implemented for HESS power distribution (see Figure 2)
- Battery and supercapacitor voltage, state of charge (SOC), and current monitored over 8 hours

Table 2: Component and system specifications

Components		Systems
Lead-Acid Battery Pack	Supercapacitor Bank	1. Traditional: battery
24V	32V	2. HESS: battery + supercapacitor
70 Ah	250 F	3. HESS: battery + supercapacitor + generator

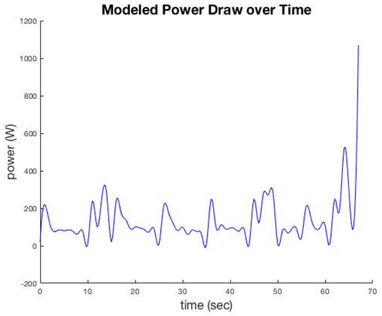

Figure 1: Simulated power draw

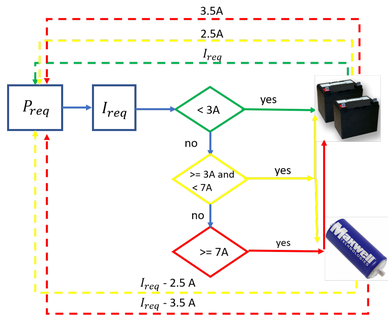

Figure 2: Power control scheme

Results

Summary of Results (graphical):

- Figure 3 shows total required current and distribution of current between battery and supercapacitor in HESS
- Figure 4 shows supercapacitor voltage, SOC, and current in HESS configuration (independent of recharging component)
- Figure 5 shows battery voltage, SOC, and current for traditional system and HESS recharging variations

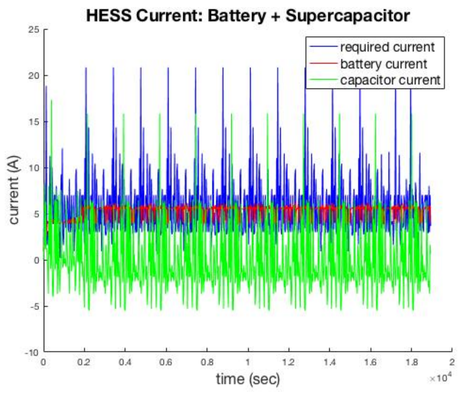

Figure 3: Simulation total required current, supercapacitor current, and battery current over 8 hours

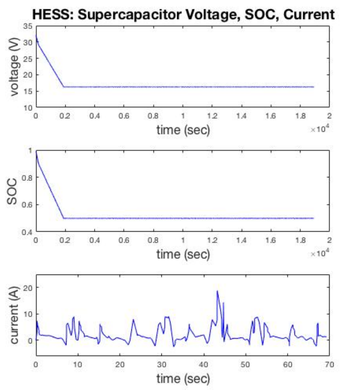

Figure 4: HESS supercapacitor voltage, SOC, and current

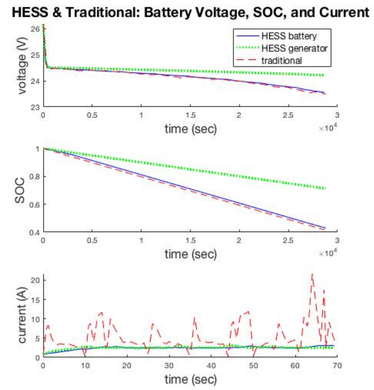

Figure 5: Battery voltage, SOC, and current for traditional system and two HESS variations

Discussion

- HESS supercapacitor takes on peak power, relieving battery of high stress: suggests potential to extend battery life
- HESS with battery recharging shows slight improvement in remaining SOC: further improvement possible with optimized control scheme
- HESS with generator recharging shows large improvement in remaining SOC: suggests ability to double range

Conclusion

- Simulations show potential to extend battery lifetime and range
- Candidate components have been ordered for testing
- Variations of testing and questions/issues to be addressed are summarized in Table 3

Table 3: Considerations for future testing

Case	Questions	Issues to Address
1. Battery pack alone (baseline)	-range (reference) -peak battery current	
2. Battery + Generator	-range improvement from 1. -peak battery current -propane required for doubled range -emissions	-recharging of battery from generator while being used
3. Battery + Supercapacitor	-range improvement from 1. -peak battery current	-circuit hardware -optimal controls -protection from short circuit current
4. Battery + Supercapacitor + Generator	-range improvement from 1. -peak battery current -propane required for doubled range -emissions	-issues from 3. -recharging of supercapacitor from generator -mechanical design to house components compactly

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