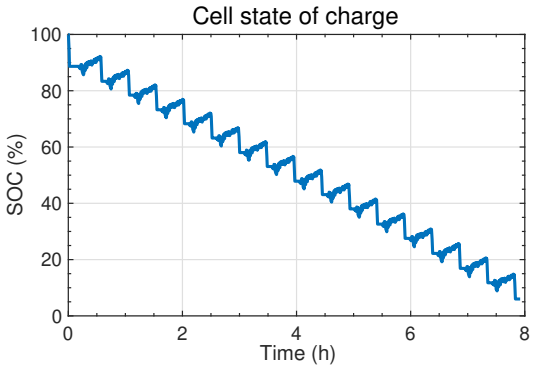
Power-limits estimation example

- We close this week with an example showing the similarities and differences between the HPPC and bisection methods
- Same experiment I shared last week
- 16 UDDS cycles, separated by discharge pulses and five-min. rests
- SOC increases by about 5 % during each cycle, brought down about 10 % during discharges
- The entire normal operating range for this cell (10 % to 90 % SOC) is excited during the cell test



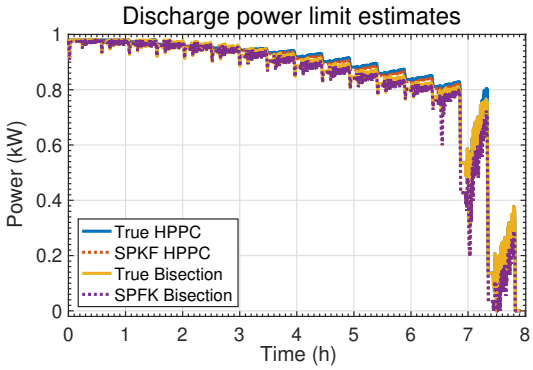
Parameters for test

- Experiment computes power for single cell, $N_s = 1$ and $N_p = 1$
- Cell has nominal capacity of 7.5 Ah, and $\Delta T = 10$ s for both charge and discharge
- Operational limits for the power calculations are listed

Parameter	Minimum	Maximum
$v_n(t)$	2.8 V	4.3 V
$i_n(t)$	−200 A	350 A
$z_n(t)$	0.1	0.9
$p_n(t)$	$-\infty$	∞

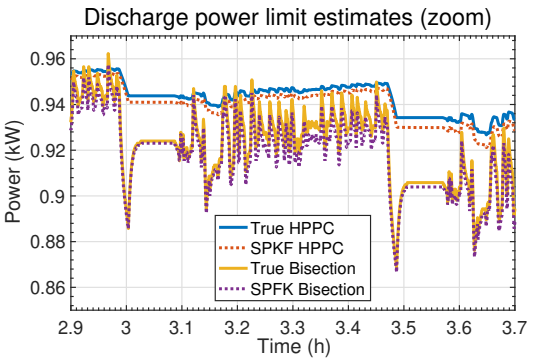
Power-limits example (discharge)

- We consider bisection results to be “true” cell capability, due to fidelity of model’s voltage estimates
- All methods produce similar estimates
- HPPC overpredicts available power most of time (doesn’t take into account general discharge trend of drive cycle, which draws voltage down below OCV)
- If vehicle were to discharge at rates permitted by HPPC, cell would be over-discharged in some cases (lower life), and under-utilized in some other cases



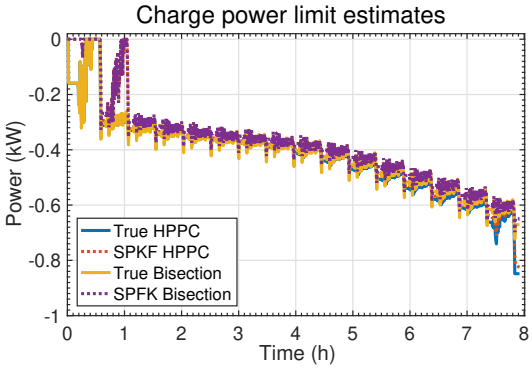
Power-limits example (discharge, zoom)

- Figure zooms in on a mid-SOC region to show greater detail
- Methods again produce similar predictions
- A notable feature of the bisection method, however, is that it takes into account entire state of cell model when making estimates
- Strong discharges at around time 3 h and 3.5 h draw voltage down: bisection allows less discharge power than HPPC computes, (as HPPC considers only SOC when making its estimate)



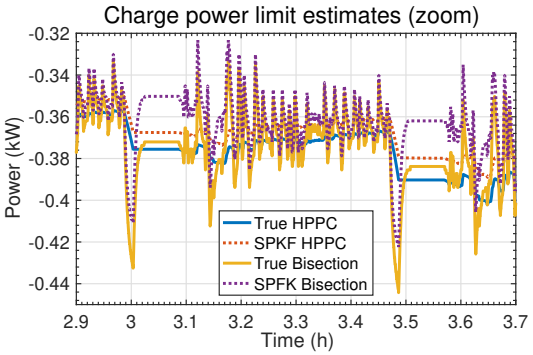
Power-limits example (charge)

- Results also compared with respect to charge power
- Recall: charge power has negative sign
- Again, all methods produce very similar results
- And, once again HPPC frequently over-predicts (absolute) charge power
- Especially so at low SOCs as it ignores increase to charge resistance at low SOC



Power-limits example (charge, zoom)

- Zoom of charge-power plot shown
- Zoom accentuates differences between the estimates
- Strong discharges at around time 3 h and 3.5 h draw voltage down:
  - Bisection correctly estimates greater (absolute) charge power as voltage will not quickly change
  - HPPC considers only SOC when making its estimate, so cannot take advantage of this knowledge



Summary

- This concludes our investigation of two methods to predict battery dis/charge power
- Both incorporate voltage, SOC, power, current constraints, work for general ΔT
- Both methods produce very similar results
- Bisection method requires significantly more computation and a good cell model
  - But, if xKF is being used to estimate SOC, then cell model will already be present and state will be available for use
- Bisection produces dynamic power estimates
  - Is able to take advantage of recent strong discharge events to increase the temporary available (absolute) charge power;
  - Is able to take advantage of recent strong charge events to increase temporary available discharge power