Comparison of Single Cell and Parallel Cell Li-ion Testing

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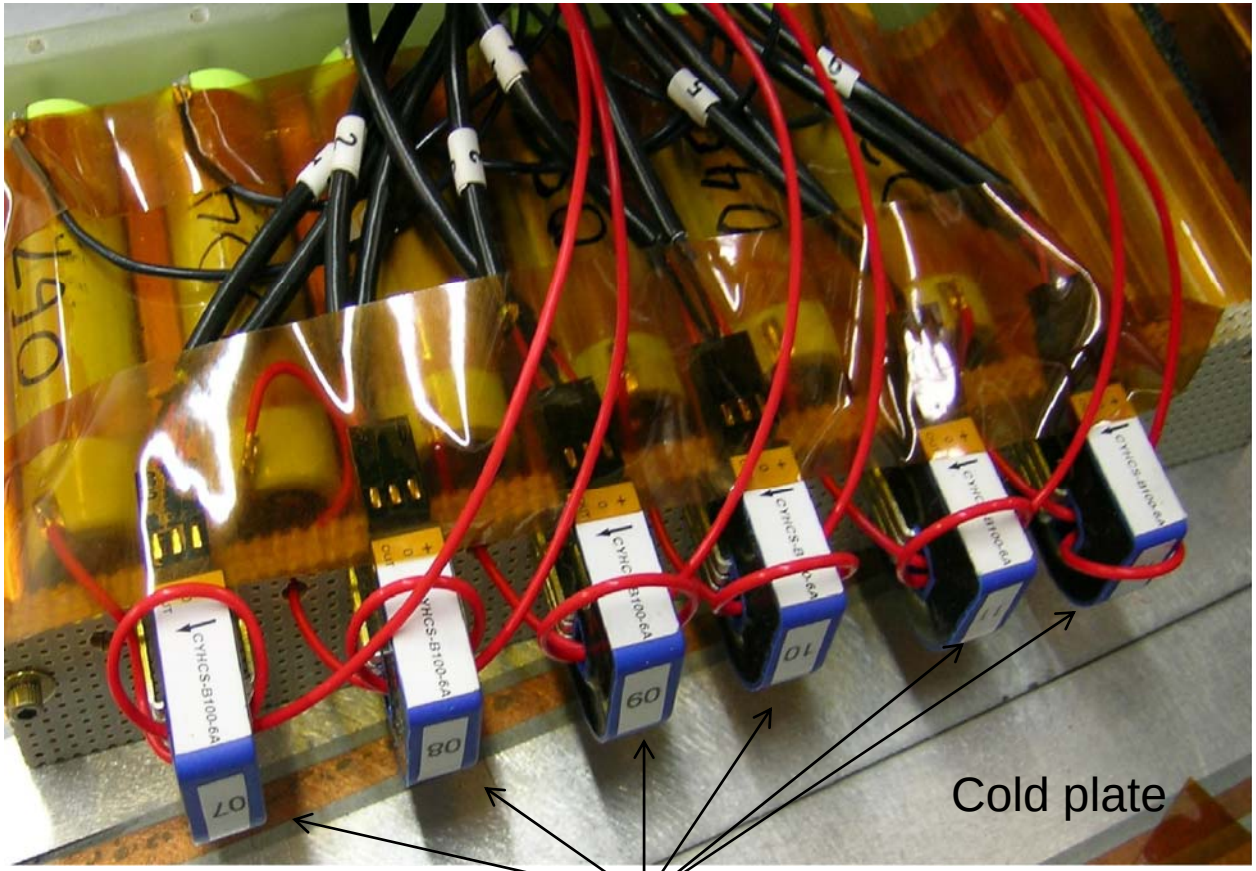
Agenda

- Test Set-up
- Comparison of well-matched cells in modules with single cells
  - *Voltage*
  - *Temperature*
  - *Current sharing*
- Performance of degraded cells in modules
  - *Individual cell performance*
  - *Voltage*
  - *Current sharing*
- Comparison of well-matched modules with degraded modules
- Summary

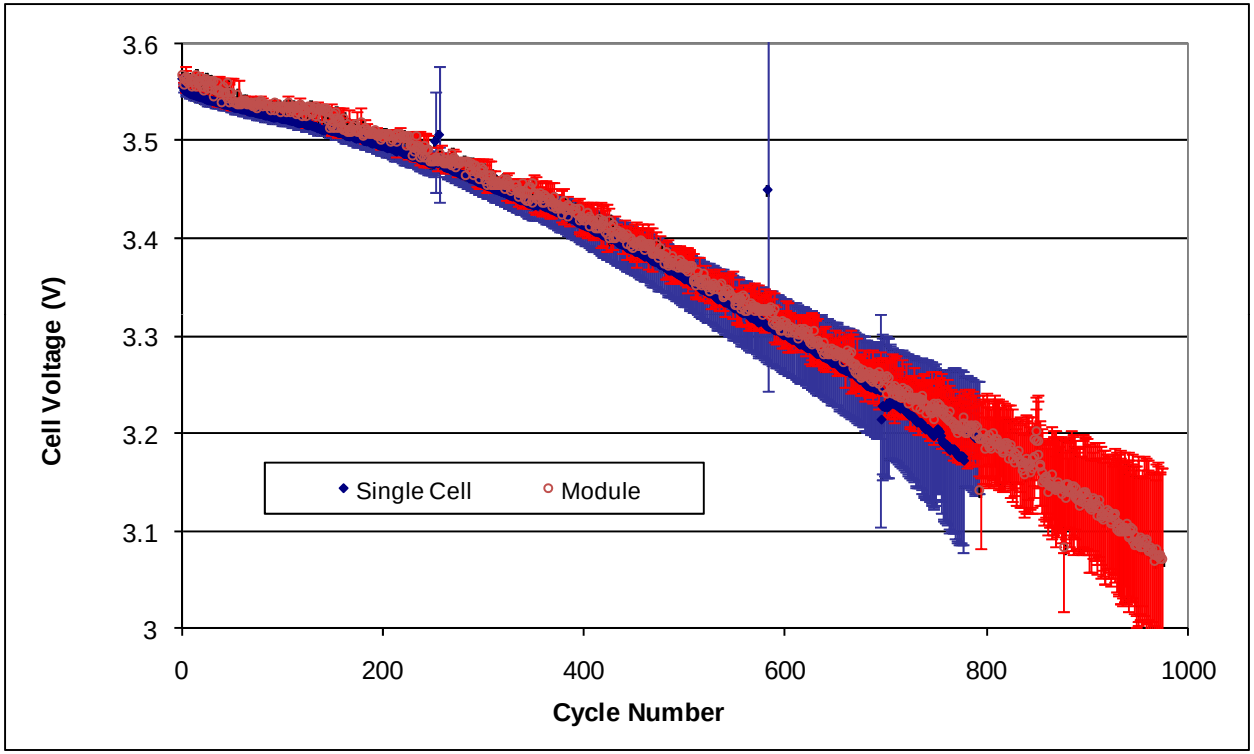
Test set-up

Cells



Hall Probes

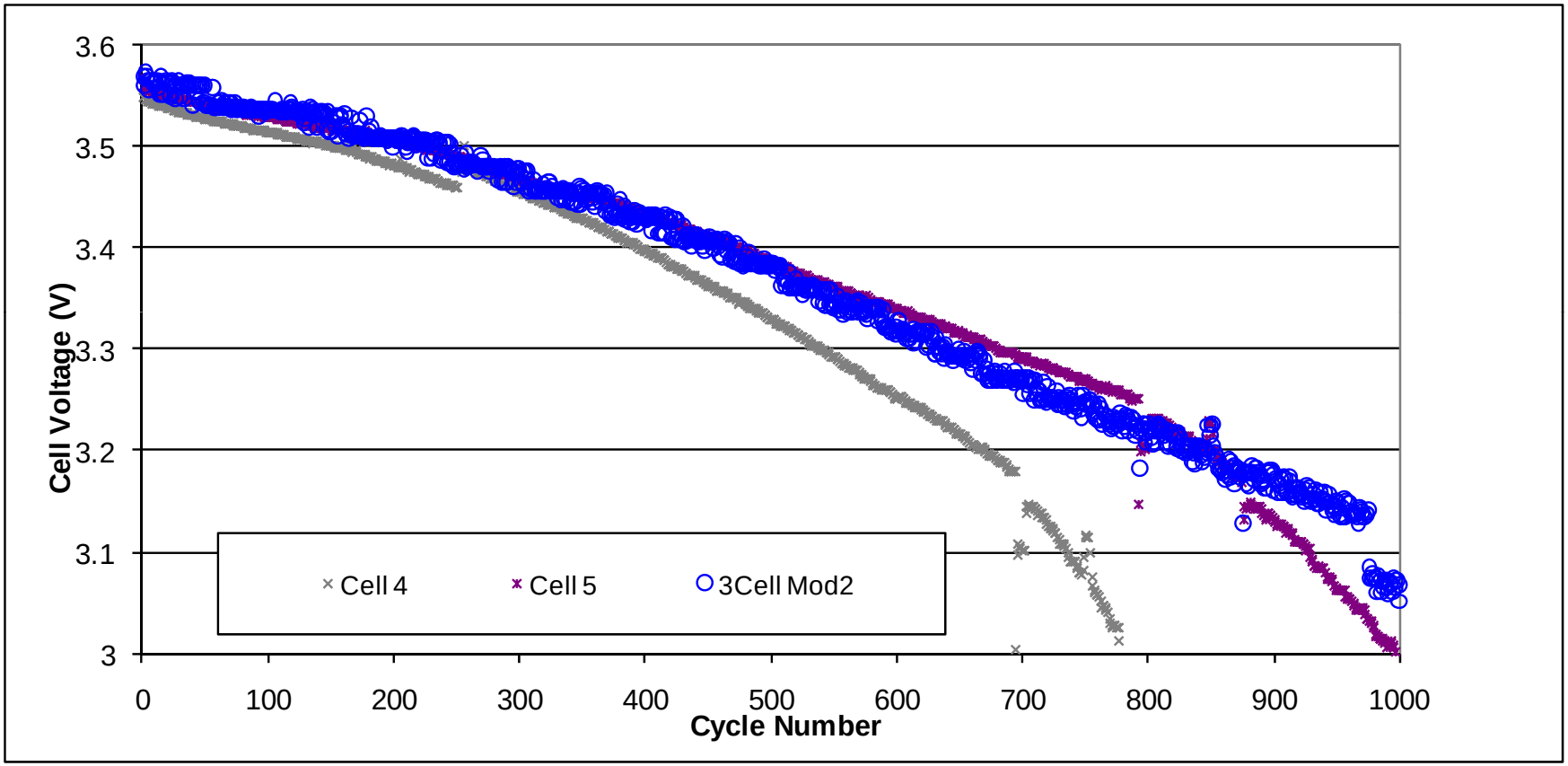
Single Cell vs Parallel Modules



Average Results

From:
6 single cells
2 3-cell modules
1 6-cell module

Single Cell vs Parallel Module: selected results



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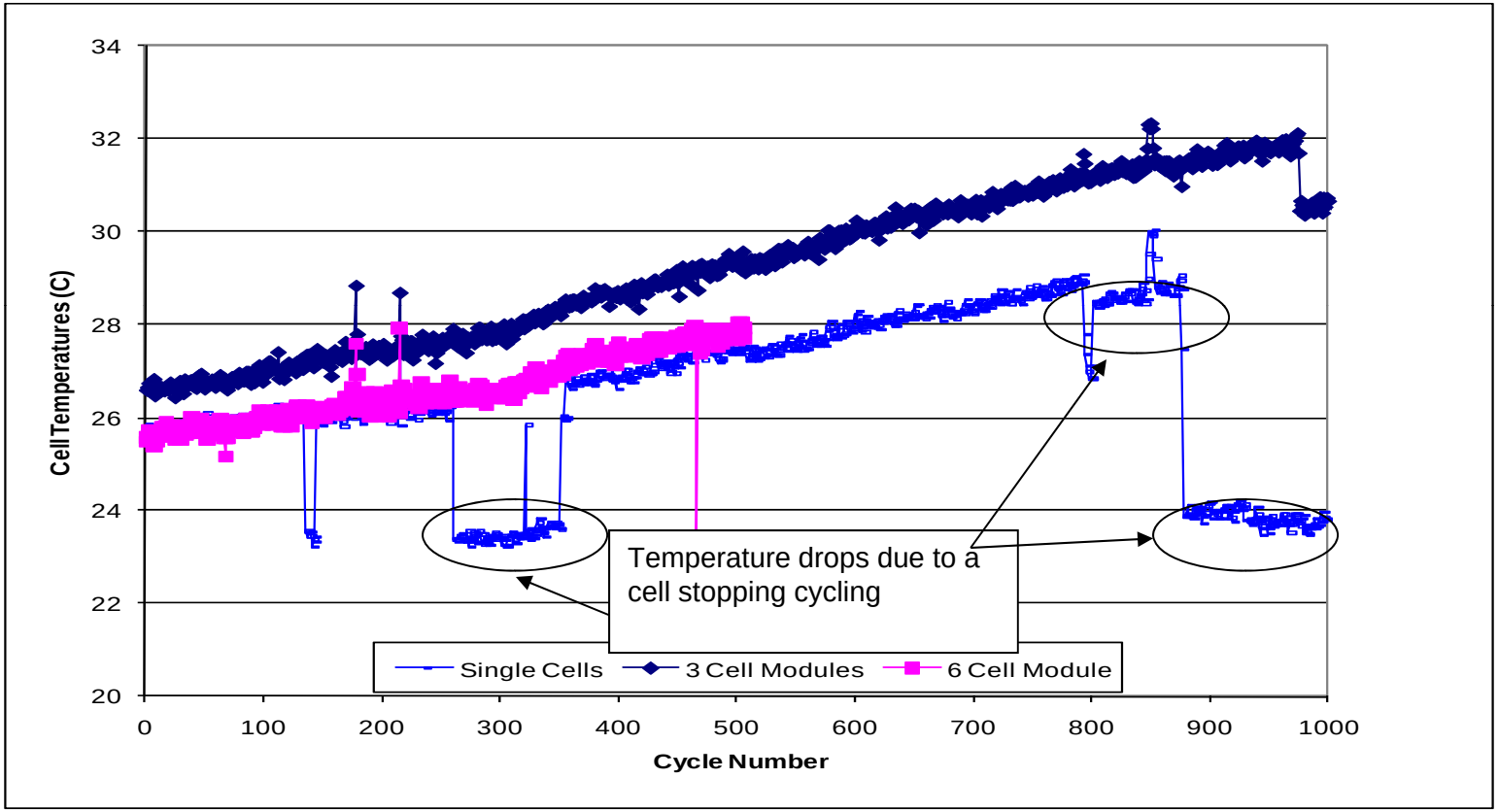
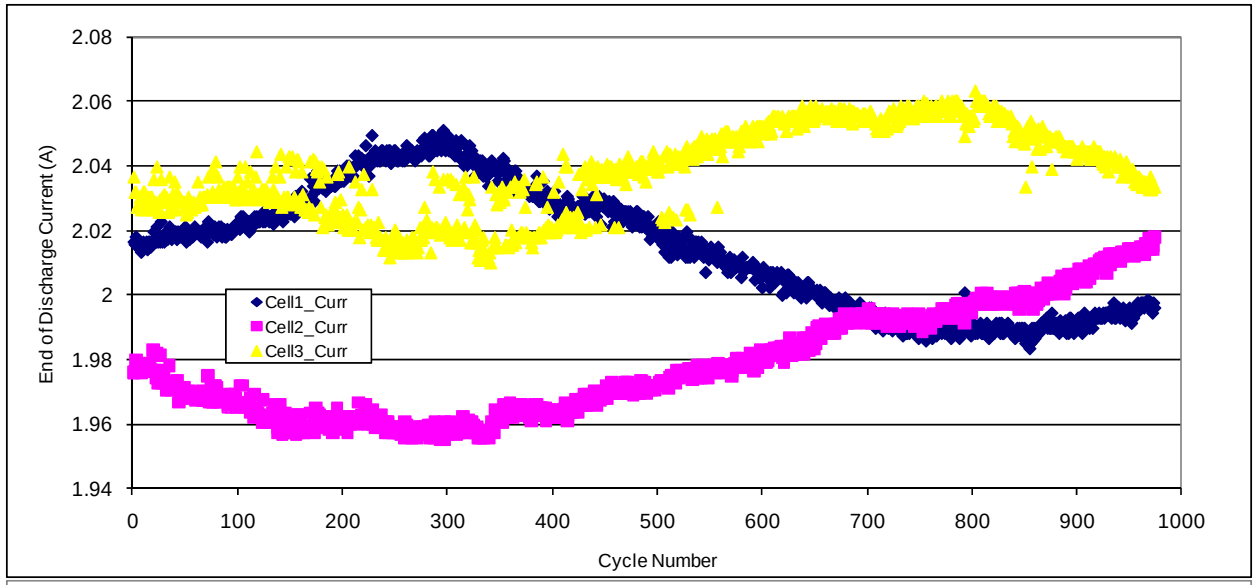
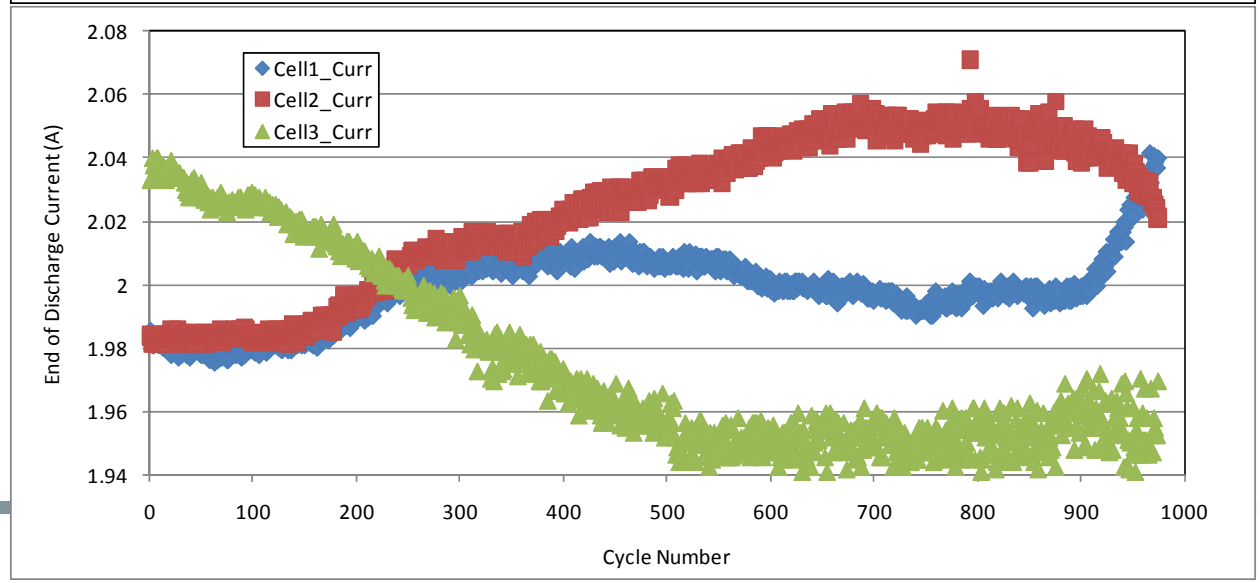
Temperatures during cycling



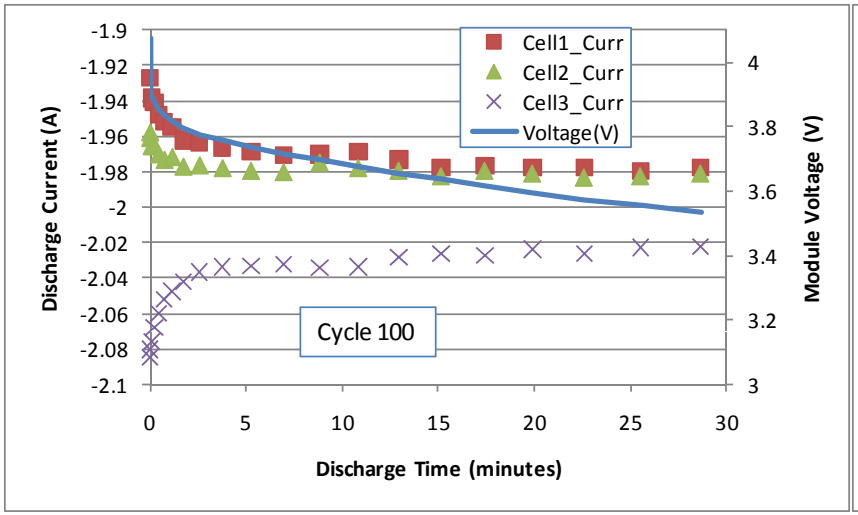
Current Sharing Between Cells in a Module

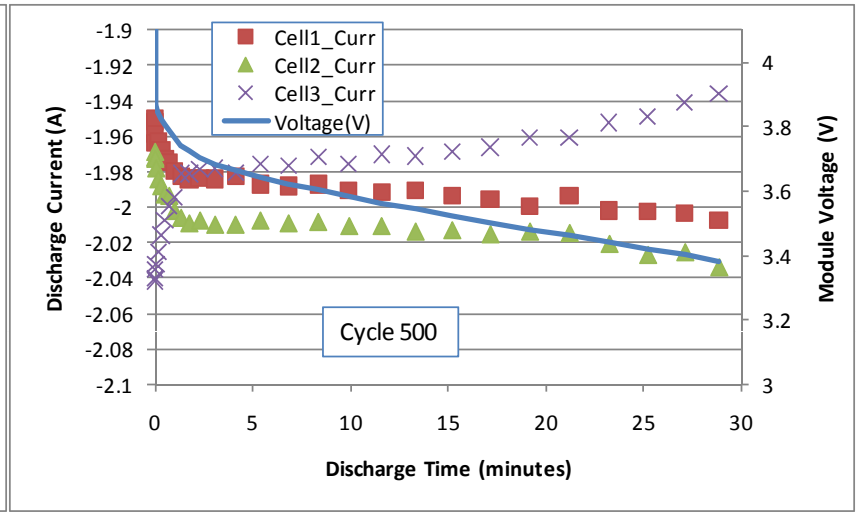


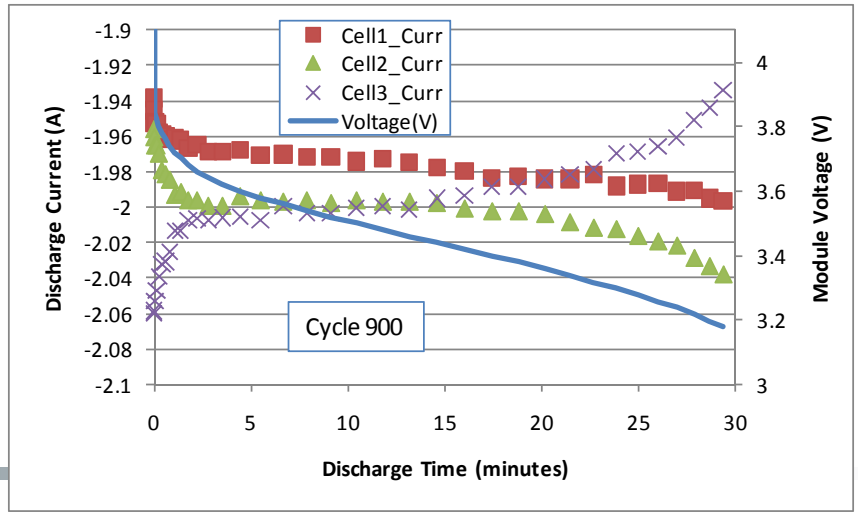


3-Cell Modules

Current Sharing during Discharge







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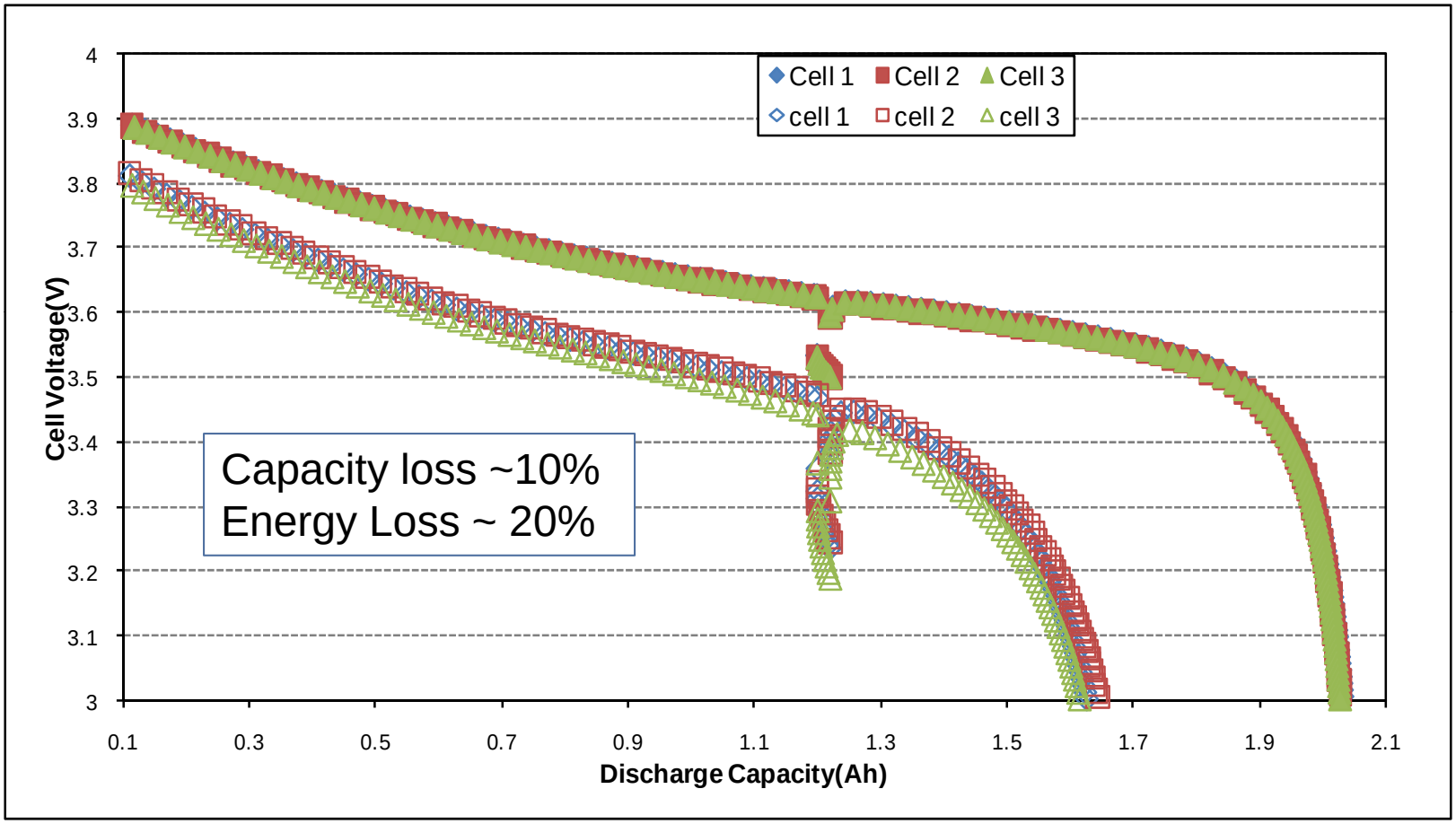
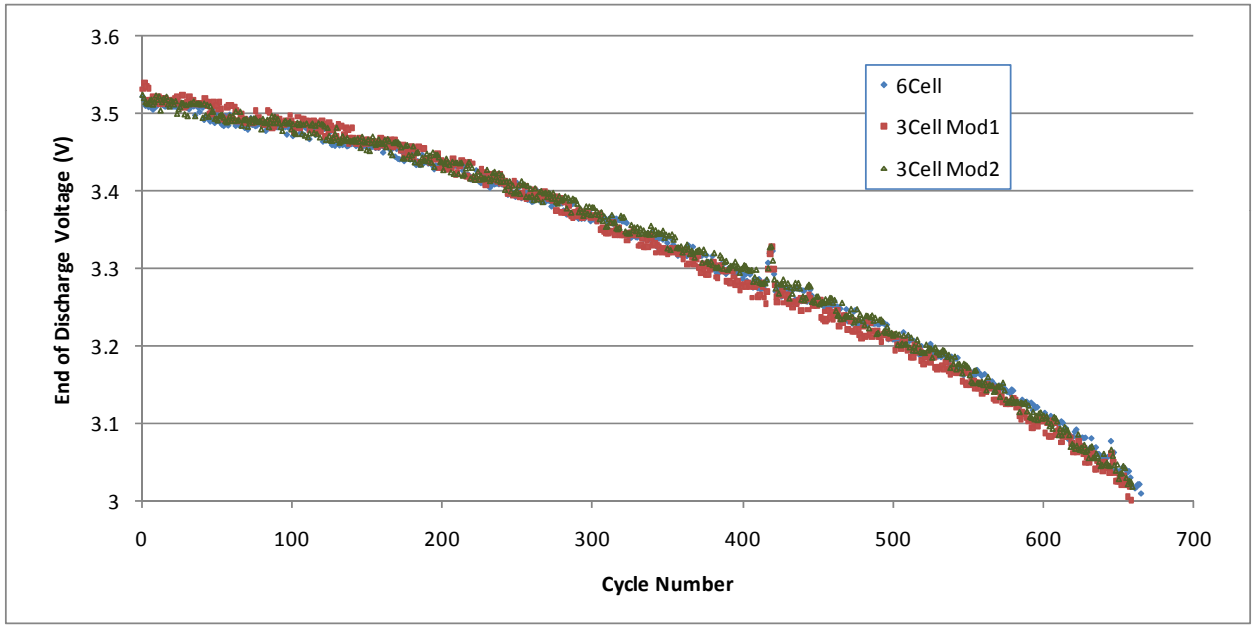
Summary of Single Cell vs Module

- No noticeable difference in performance
- Significant impact of temperature on performance
  - *particularly towards the end of life*
- Current sharing may assist in identifying weak cells

Degraded Cells Performance



Degraded Modules Stress Cycling



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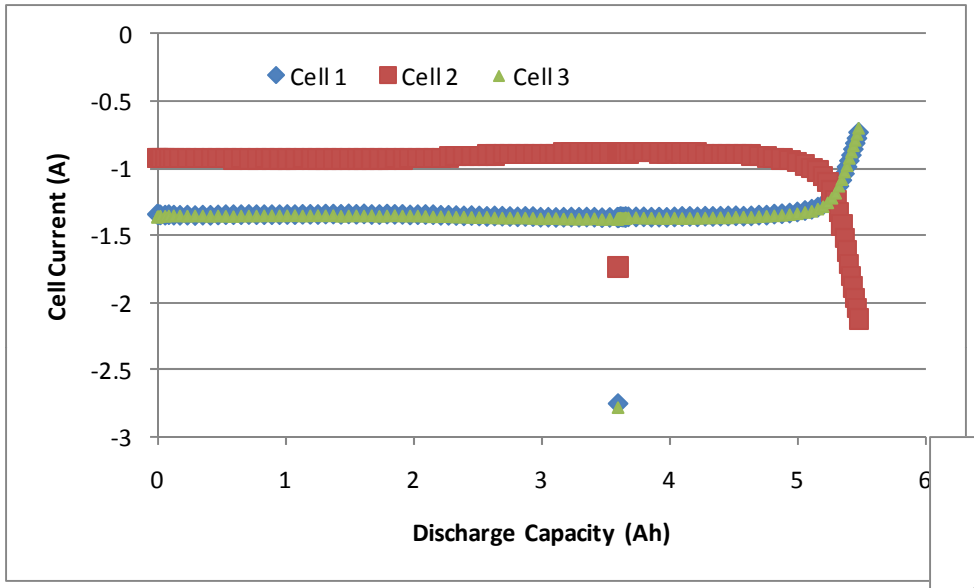
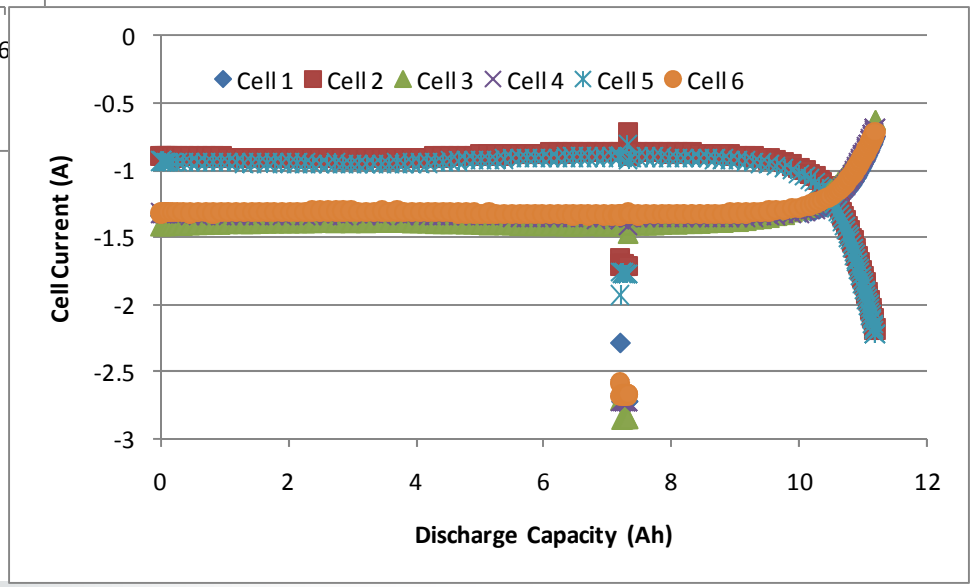
Current Sharing within Modules

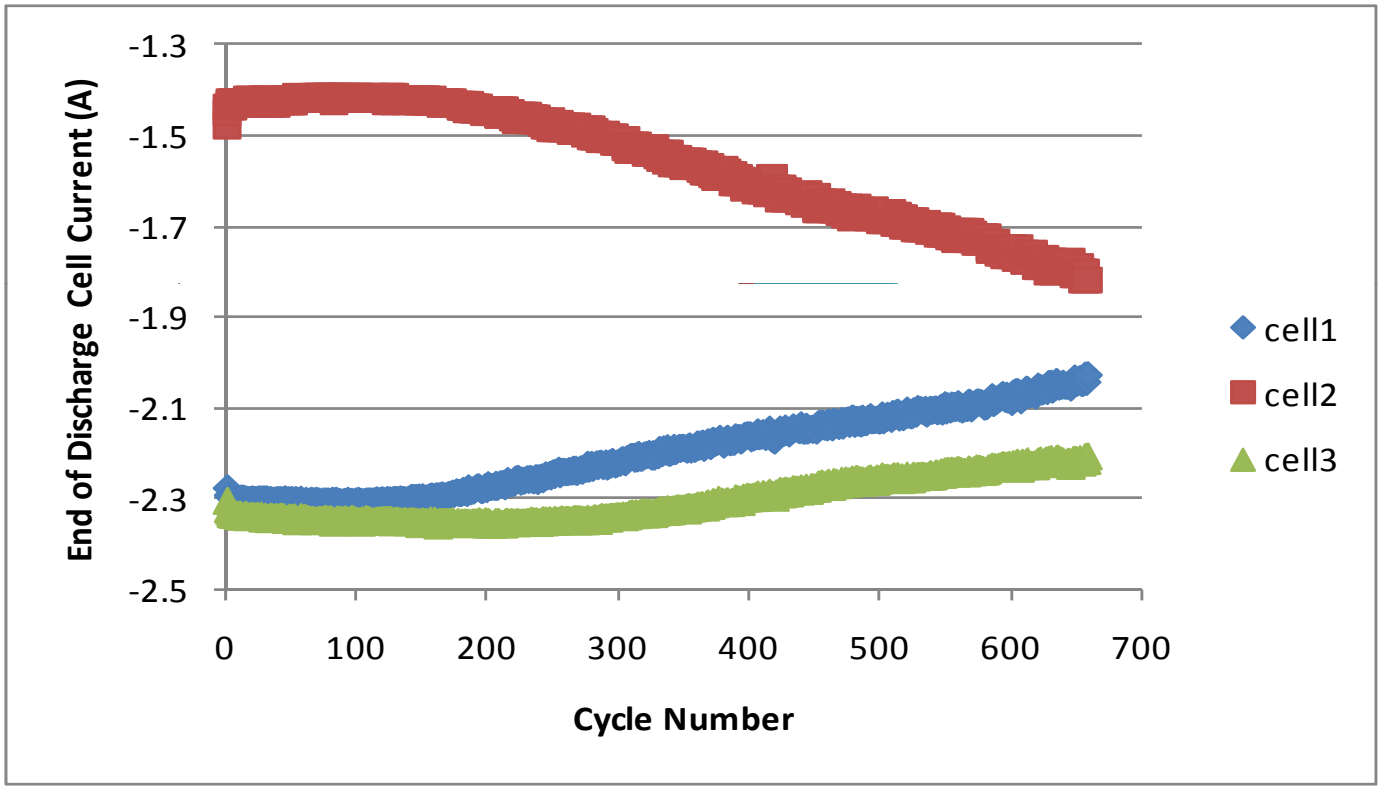


3-Cell Module

6-Cell Module

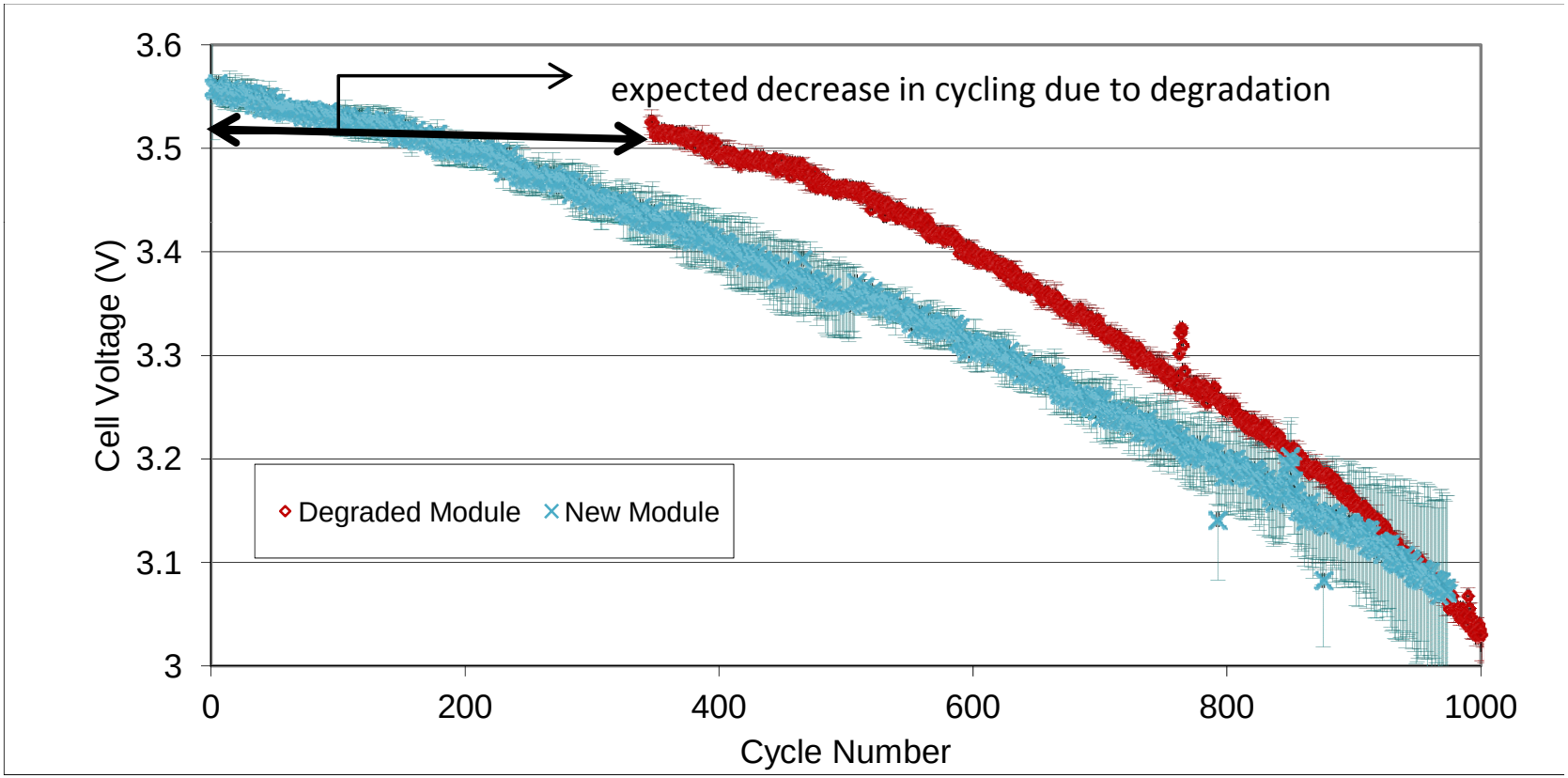


Current Sharing in Degraded Modules with Cycling



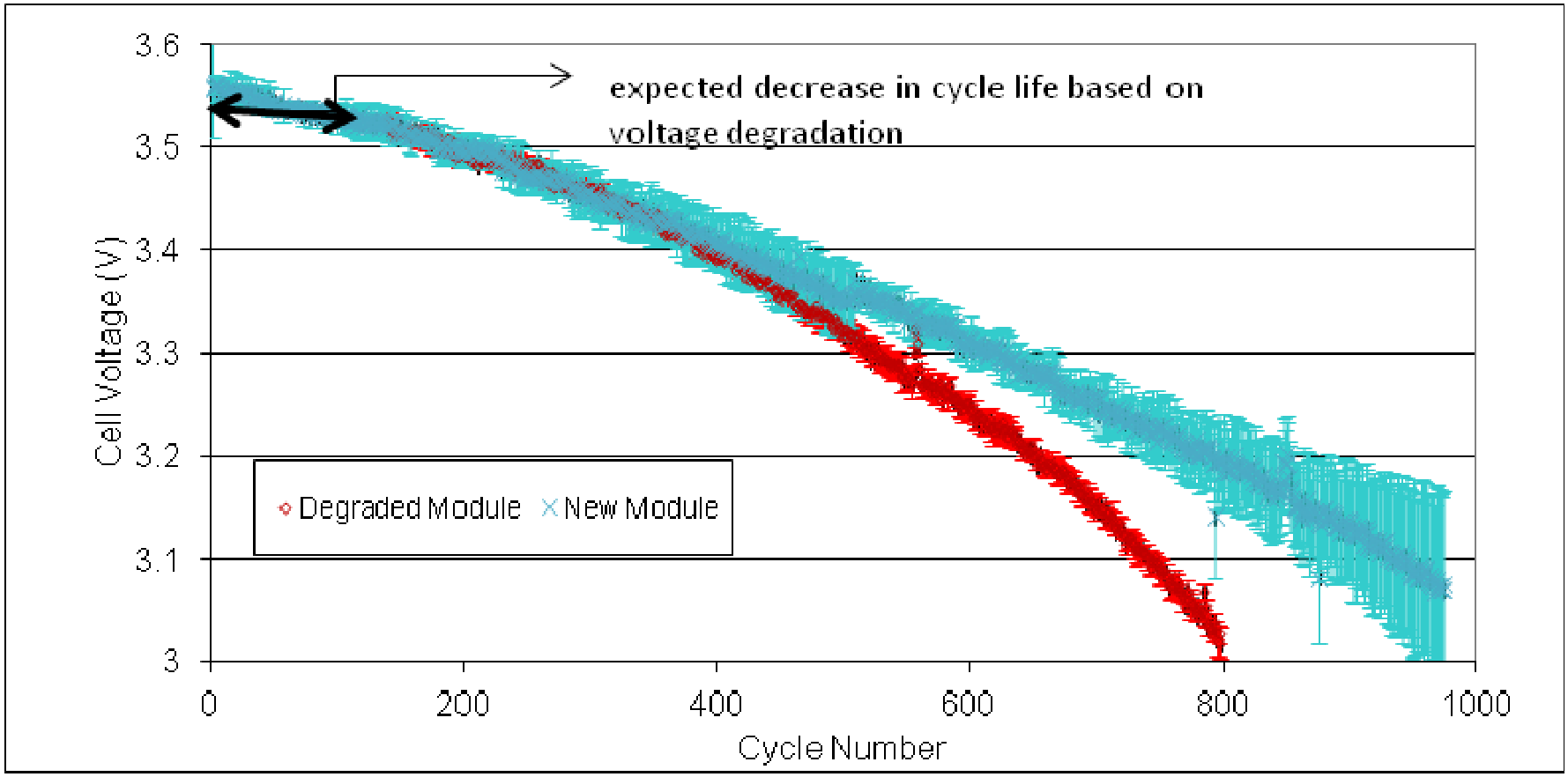
Comparison with well-matched module results

Off-set due to known degradation: 1/3 of cycle life
1 out of 3 cells could not support cycling conditions



Comparison with well-matched module results

Off-set based on end-of-discharge voltages



Summary of Module Testing with Degraded Cells

- The degraded modules demonstrate a reduced life that is in-line with known degradation of the individual cell
- This degradation was not observed through either capacity measurement or module voltage trends
- The testing highlighted that module end of discharge voltage is not a good indicator of state of health of the module by itself
  - *Current sharing between cells may be required in order to provide a more complete indication of the state of health of the module*
- Extrapolation of life estimates using the end-of-discharge voltage demonstrate 20% difference in cycle life capability based on the test set-up used.

Acknowledgements

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Back-up

Abstract

- Stress cycle testing was set up and run on Li-ion 18650 cells to compare cell and module performance. The cells were either cycled individually, in 3-cell parallel modules or 6-cell parallel modules. The cells and well-matched modules demonstrated no noticeable difference in performance during the stress cycling. During the testing it was noticed that slight differences in temperature of 2-3°C had a large impact on performance. These differences were caused by chiller outages or test stoppages that resulted in reduced heat loads on neighboring cells, the changes in voltage were particularly pronounced at end-of-life. Modules were observed to have less variation in performance than single cells, as might be expected, due to the modules averaging the individual cell performance differences. From the testing on well matched-modules it appears that single cell life test data can be used for module performance as well. Stress cycle testing on modules with degraded cells in the module was also completed. Comparison with modules with no degraded cells has been made. The degraded modules demonstrated a slight reduction in capacity, with a much larger reduction in cycle life. This cycle life degradation was not evident in either initial capacity measurement or module end-of-discharge voltage trends. The testing highlighted that module end of discharge voltage is not a good indicator of state of health of the module. Extrapolation of life estimates using the end-of-discharge voltage demonstrate 20% difference in cycle life capability based on the test set-up used. Current sharing between cells may provide a much better indication of state of health of the module.

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