



ABSTRACT

The BQ76952 family of battery monitors data sheet ([SLUSE13](#)) specifies an absolute maximum voltage of 85 V on select high-voltage pins. However, questions arise regarding the effect of higher voltage being applied to these pins during operation. While TI does not warranty device operation outside specified data sheet limits, this document provides experimental data obtained by exposing a sampling of devices to excessive voltage.

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1 Introduction

The BQ76952 family of battery monitors supports battery pack configurations with up to 16-series cells. The production data sheet for this family specifies an absolute maximum voltage limit of 85 V on select high voltage pins, with a recommended maximum voltage level of 80 V. A stack of 16 lithium-ion cells with maximum voltage of, for example, 4.2 V, would result in a top-of-stack voltage of 67.2 V.

The device also incorporates high-side NFET drivers with an integrated charge pump, which has a programmable typical voltage of 5.7 V or 11 V, and a maximum level of 7 V or 13 V, respectively. This means with a fully charged battery pack and NFET drivers enabled, the voltage on the driver pins can reach a maximum level of $67.2\text{ V} + 7\text{ V} = 74.2\text{ V}$ or $67.2\text{ V} + 13 = 80.2\text{ V}$ during operation.

However, in some systems the top-of-stack voltage may experience transients due to dynamic charge or discharge events, which may result in brief voltages exceeding these levels during operation. TI does not warranty device operation under conditions in excess of the limits specified in the production data sheet. For informational purposes, an experiment was performed by exposing a population of BQ76952 devices to excessive voltage levels, with the results described in the following sections.

2 Setup

To evaluate the effect of high-voltage stress on the device, a set of 35 devices were tested using the procedure described below.

1. The devices were first tested, and selected parameters were logged for later comparison.
2. The OTP in each device was programmed such that the charge pump would be powered and the high-side CHG and DSG protection FET drivers would be enabled by default during the testing.
3. Selected pins on each device were connected through passive components to a single voltage source (initially set to 0 V), as shown in the schematic in [Figure 2-1](#).
4. The circuit was placed into an oven and the voltage source was slowly ramped from 0 V to 120 V with a rise time of approximately 5 seconds. The voltage source was limited to an output current of 5 mA.
5. With the 120-V source held constant, the oven was heated to 85°C over the course of approximately 10 minutes.
6. The voltage source was powered down, and the devices were removed from the oven.
7. Devices were retested, and the selected parameters were logged and compared to those taken earlier.

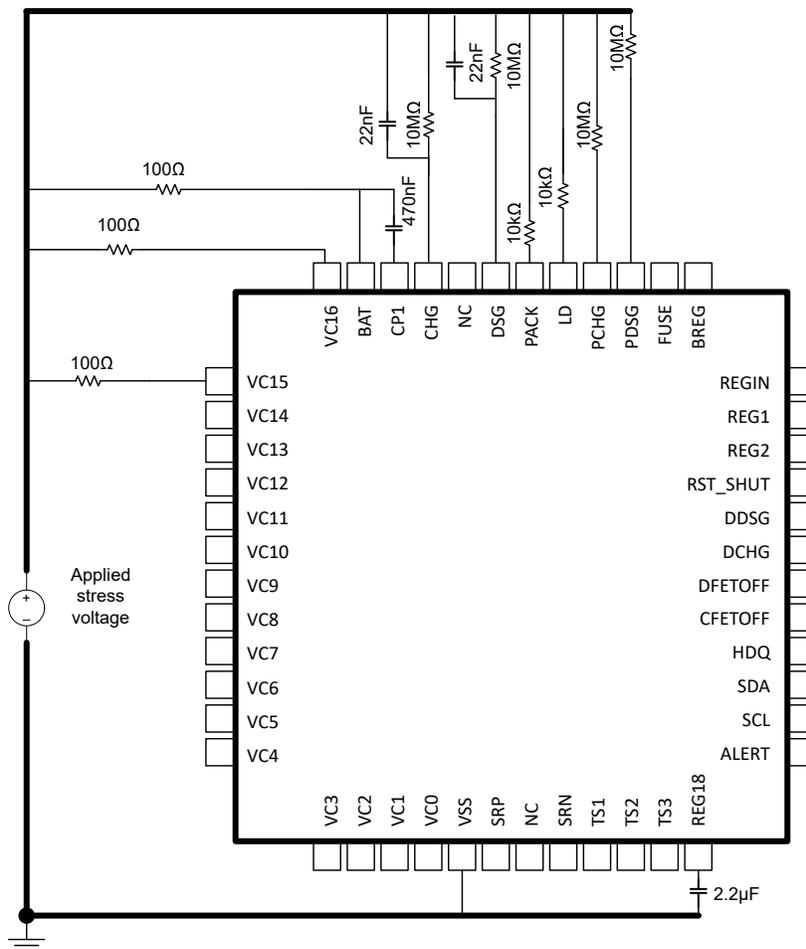


Figure 2-1. Schematic of System Used for Voltage Stress

3 Measurement Data

During the testing, no incidents of component breakdown or latchup were observed on any of the devices. The following plots show the pre-stress and post-stress results for each cell voltage measurement using a 1-V and 4-V input, as well as selected Short Circuit in Discharge (SCD), Overcurrent in Discharge 1 (OCD1), and Overcurrent in Charge (OCC) thresholds. The plots titled "Delta in ..." show the difference in the post-stress and pre-stress measurements on each specific device.

3.1 Graphical Data

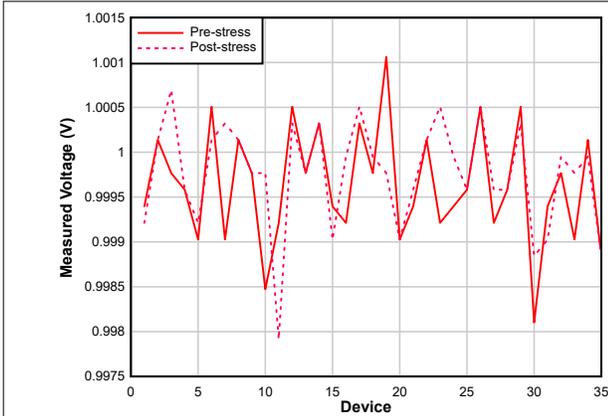


Figure 3-1. VC1-VC0 Measurement with 1-V Input

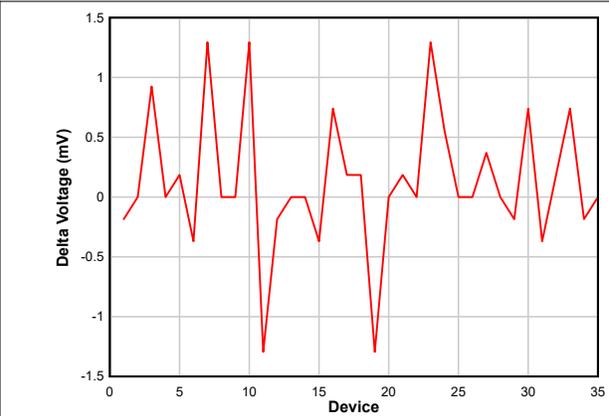


Figure 3-2. Delta in VC1-VC0 Measurements with 1-V Input

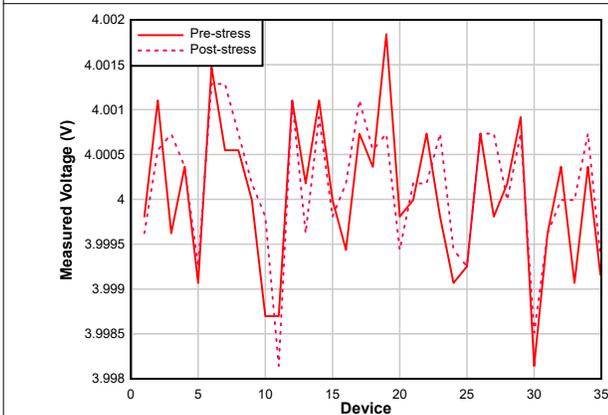


Figure 3-3. VC1-VC0 Measurement with 4-V Input

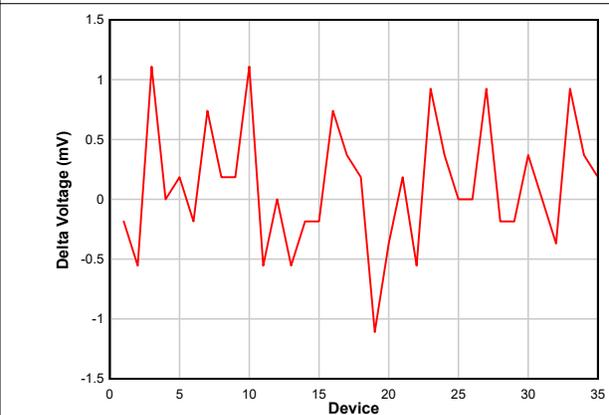


Figure 3-4. Delta in VC1-VC0 Measurements with 4-V Input

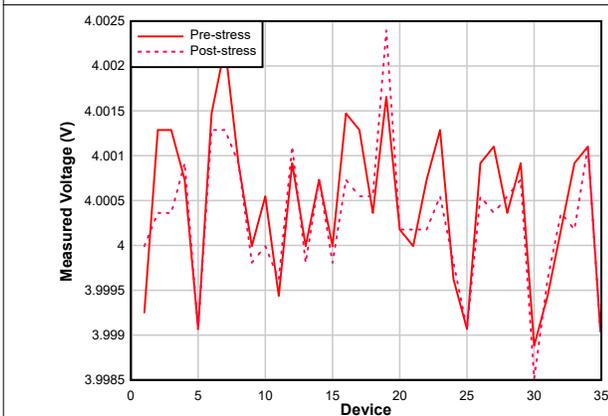


Figure 3-5. VC2-VC1 Measurement with 4-V Input

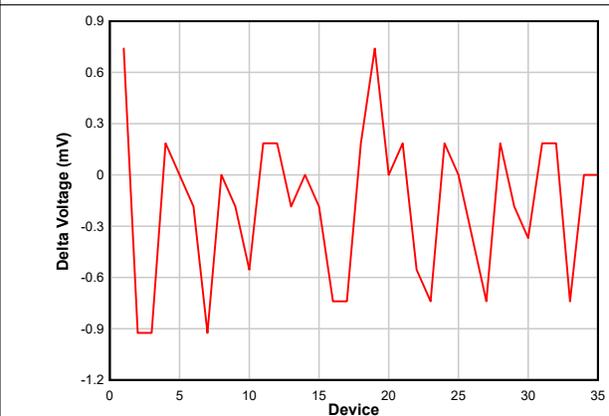


Figure 3-6. Delta in VC2-VC1 Measurements with 4-V Input

3.1 Graphical Data (continued)

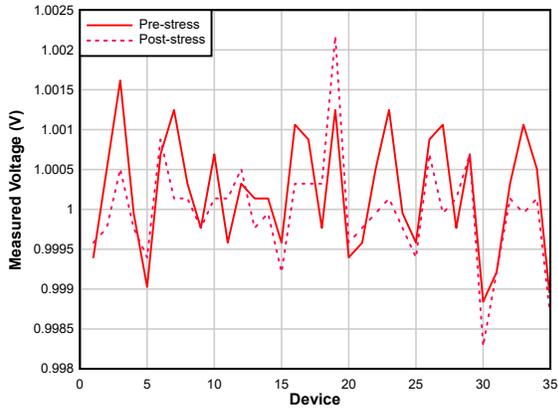


Figure 3-7. VC2-VC1 Measurement with 1-V Input

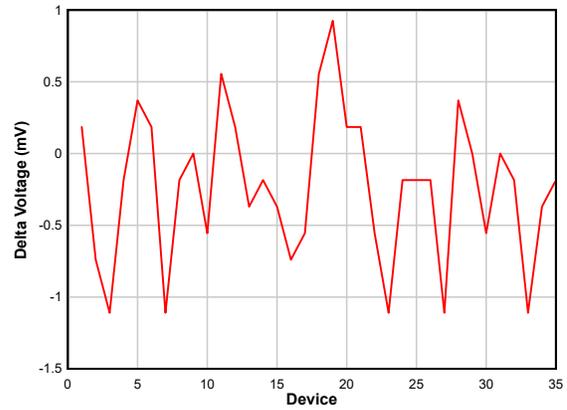


Figure 3-8. Delta in VC2-VC1 Measurements with 1-V Input

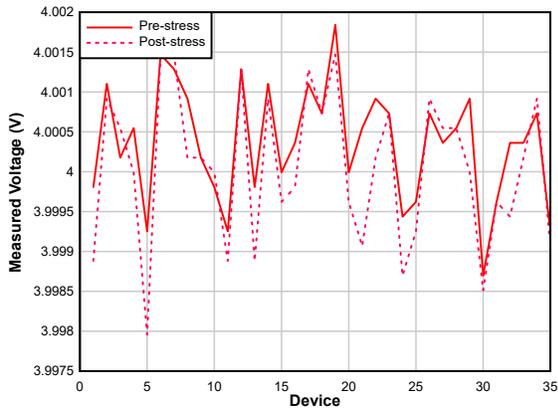


Figure 3-9. VC3-VC2 Measurement with 4-V Input

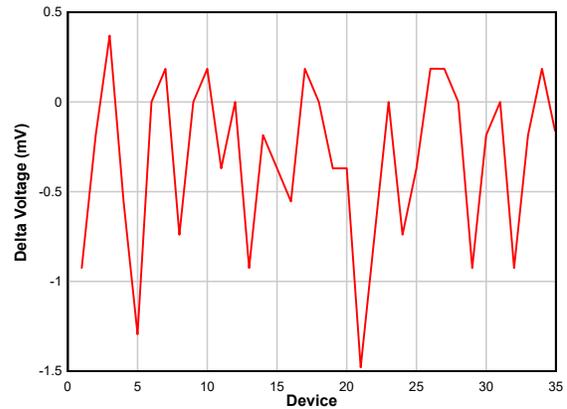


Figure 3-10. Delta in VC3-VC2 Measurements with 4-V Input

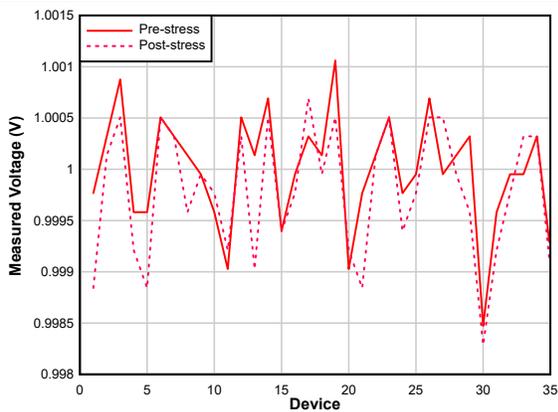


Figure 3-11. VC3-VC2 Measurement with 1-V Input

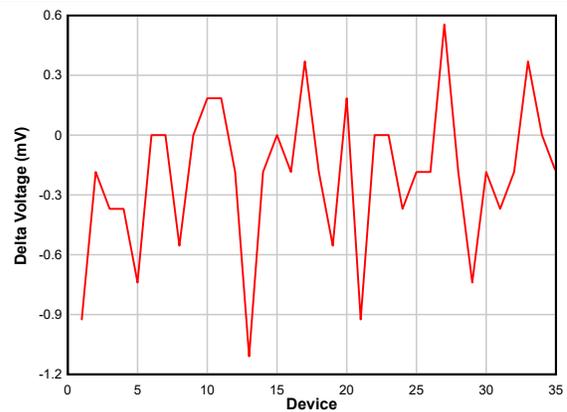


Figure 3-12. Delta in VC3-VC2 Measurements with 1-V Input

3.1 Graphical Data (continued)

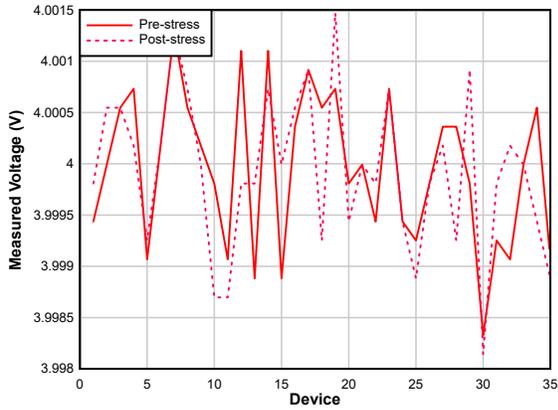


Figure 3-13. VC4-VC3 Measurement with 4-V Input

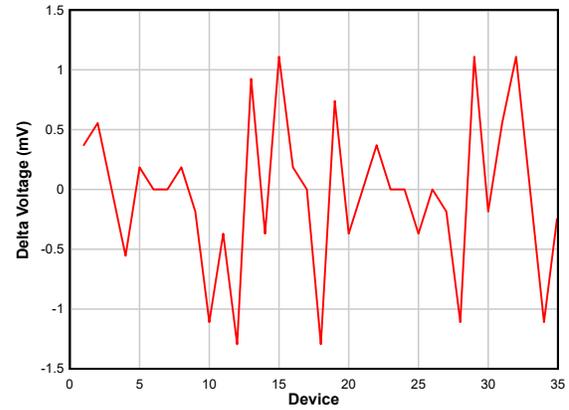


Figure 3-14. Delta in VC4-VC3 Measurements with 4-V Input

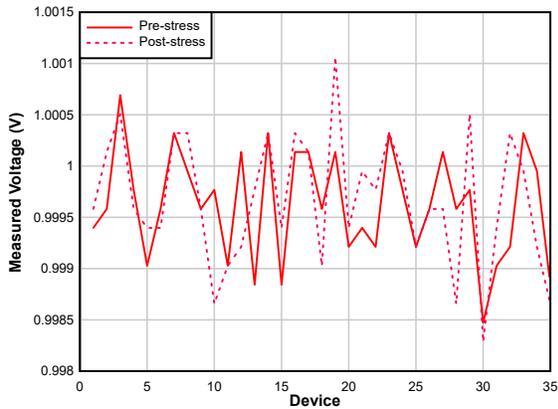


Figure 3-15. VC4-VC3 Measurement with 1-V Input

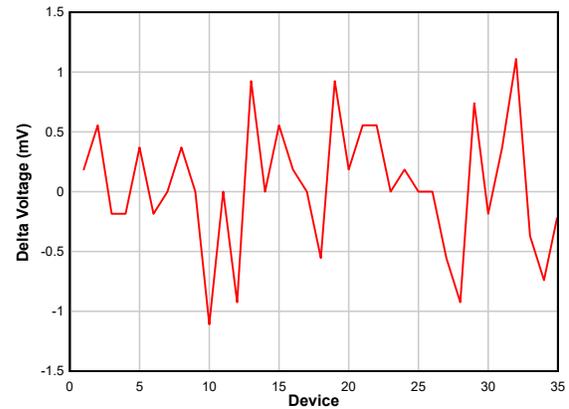


Figure 3-16. Delta in VC4-VC3 Measurements with 1-V Input

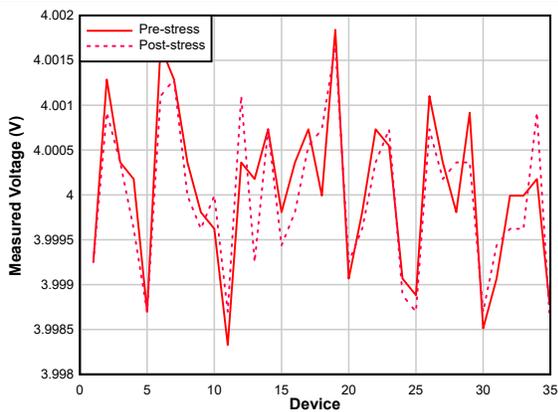


Figure 3-17. VC5-VC4 Measurement with 4-V Input

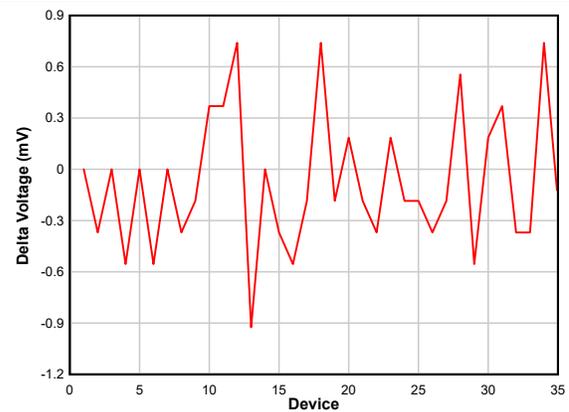


Figure 3-18. Delta in VC5-VC4 Measurements with 4-V Input

3.1 Graphical Data (continued)

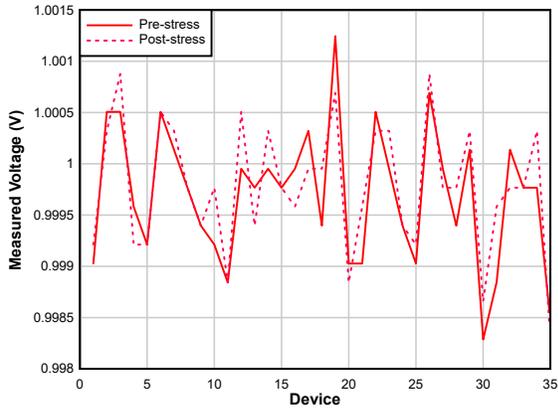


Figure 3-19. VC5-VC4 Measurement with 1-V Input

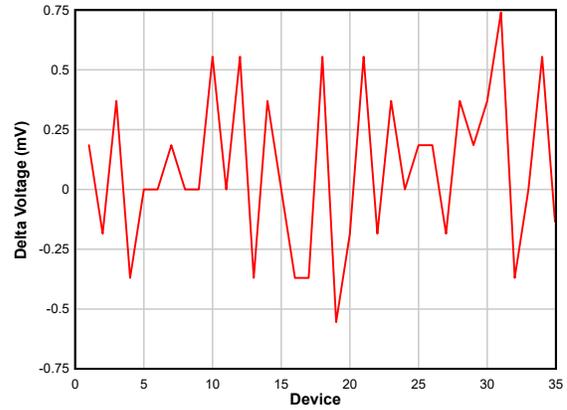


Figure 3-20. Delta in VC5-VC4 Measurements with 1-V Input

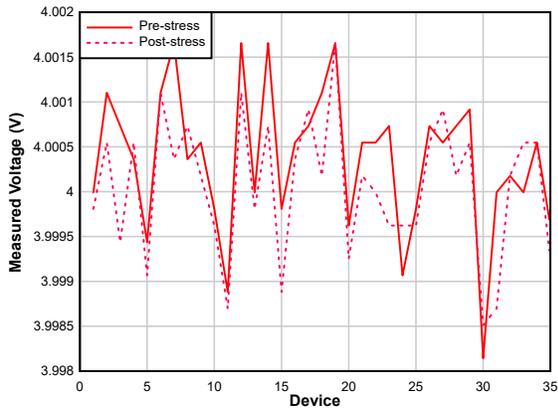


Figure 3-21. VC6-VC5 Measurement with 4-V Input

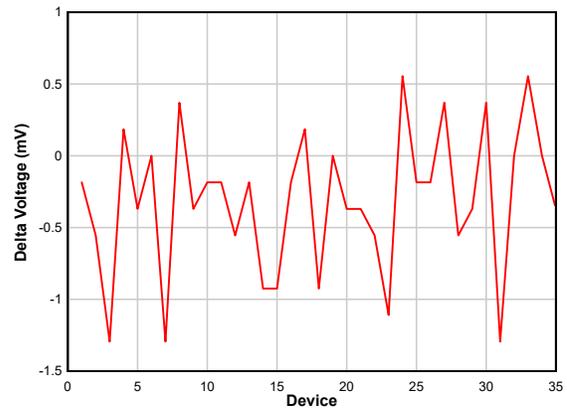


Figure 3-22. Delta in VC6-VC5 Measurements with 4-V Input

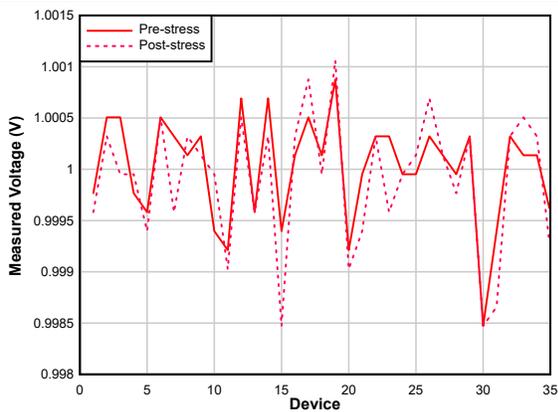


Figure 3-23. VC6-VC5 Measurement with 1-V Input

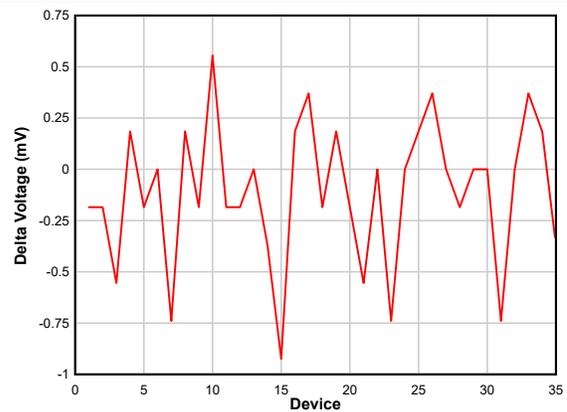


Figure 3-24. Delta in VC6-VC5 Measurements with 1-V Input

3.1 Graphical Data (continued)

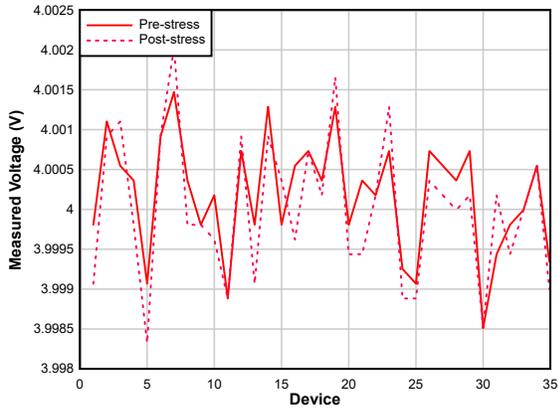


Figure 3-25. VC7-VC6 Measurement with 4-V Input

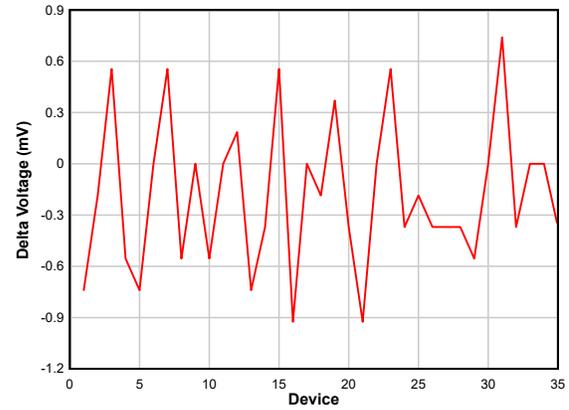


Figure 3-26. Delta in VC7-VC6 Measurements with 4-V Input

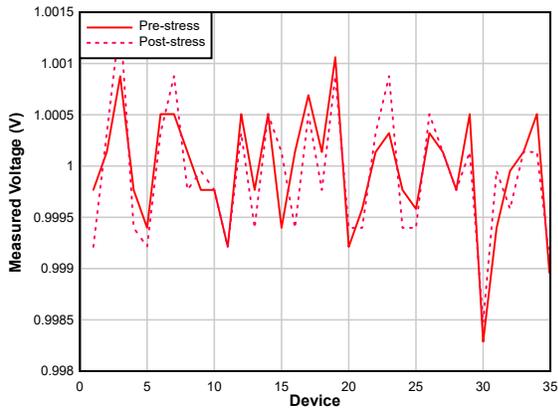


Figure 3-27. VC7-VC6 Measurement with 1-V Input

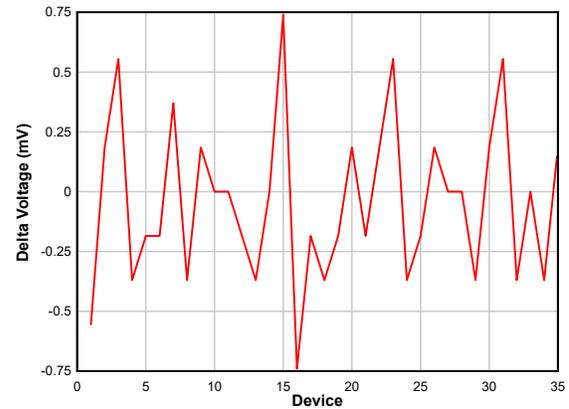


Figure 3-28. Delta in VC7-VC6 Measurements with 1-V Input

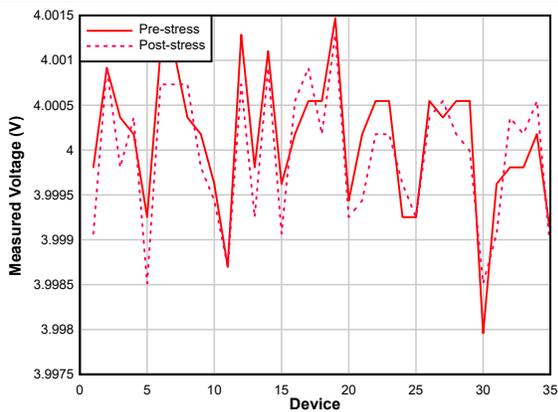


Figure 3-29. VC8-VC7 Measurement with 4-V Input

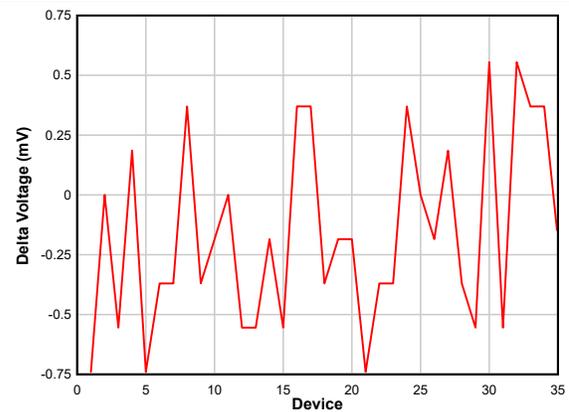


Figure 3-30. Delta in VC8-VC7 Measurements with 4-V Input

3.1 Graphical Data (continued)

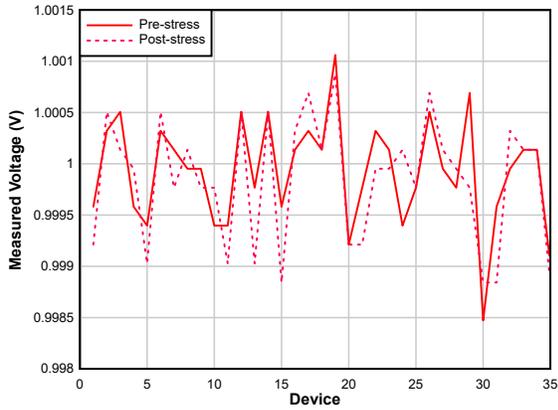


Figure 3-31. VC8-VC7 Measurement with 1-V Input

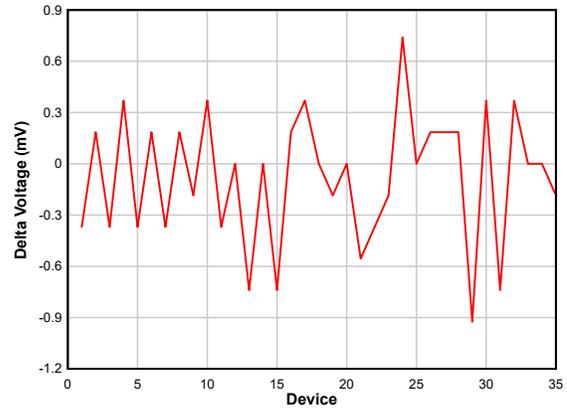


Figure 3-32. Delta in VC8-VC7 Measurements with 1-V Input

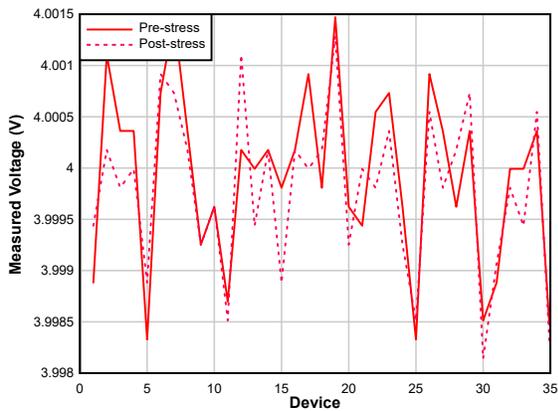


Figure 3-33. VC9-VC8 Measurement with 4-V Input

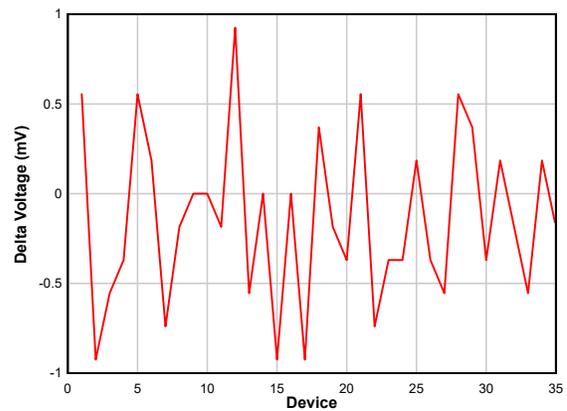


Figure 3-34. Delta in VC9-VC8 Measurements with 4-V Input

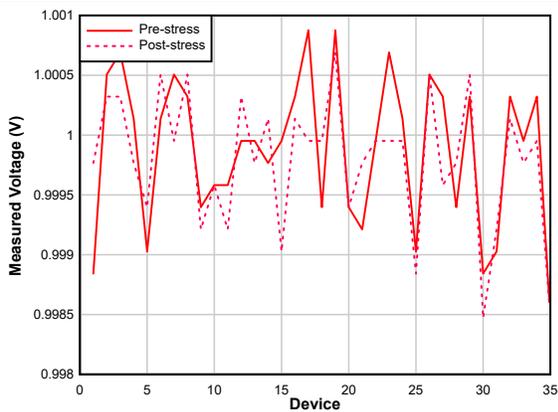


Figure 3-35. VC9-VC8 Measurement with 1-V Input

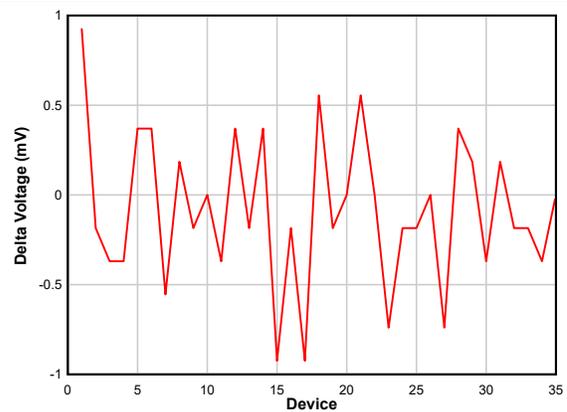


Figure 3-36. Delta in VC9-VC8 Measurements with 1-V Input

3.1 Graphical Data (continued)

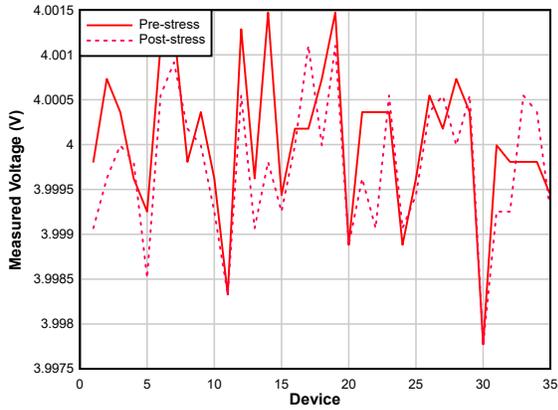


Figure 3-37. VC10-VC9 Measurement with 4-V Input

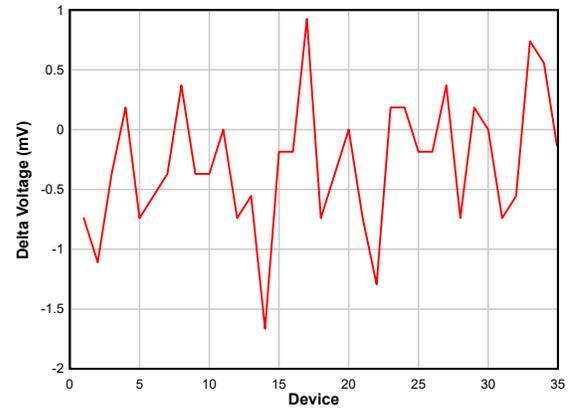


Figure 3-38. Delta in VC10-VC9 Measurements with 4-V Input

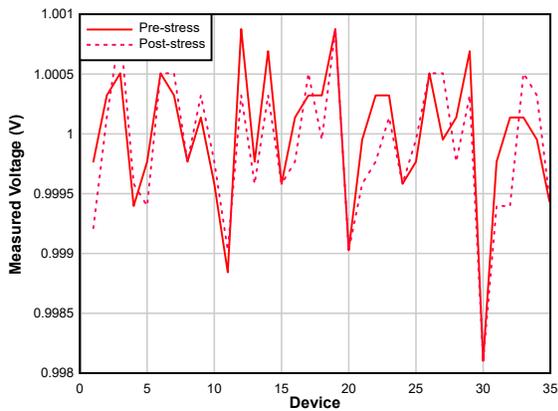


Figure 3-39. VC10-VC9 Measurement with 1-V Input

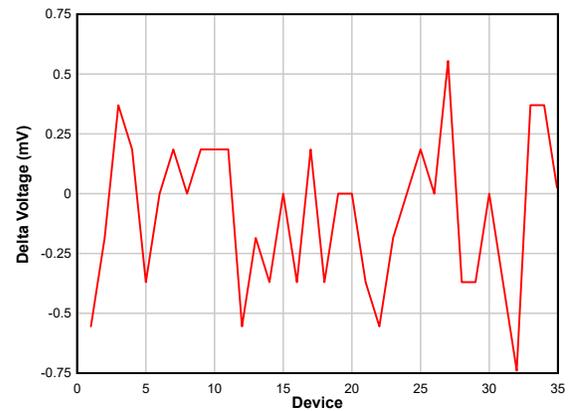


Figure 3-40. Delta in VC10-VC9 Measurements with 1-V Input

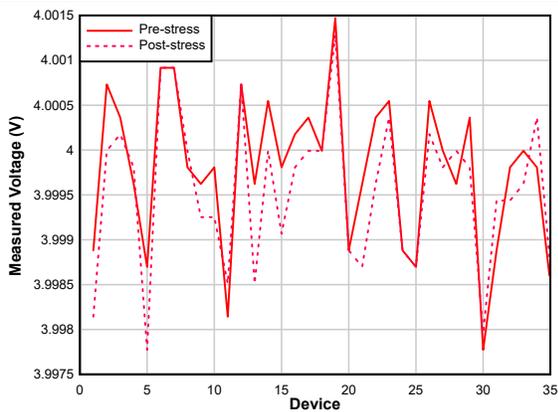


Figure 3-41. VC11-VC10 Measurement with 4-V Input

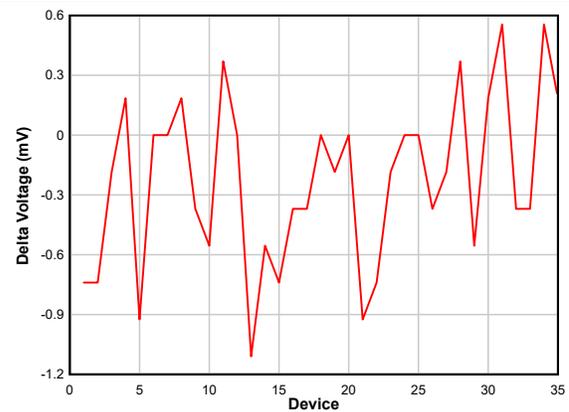


Figure 3-42. Delta in VC11-VC10 Measurements with 4-V Input

3.1 Graphical Data (continued)

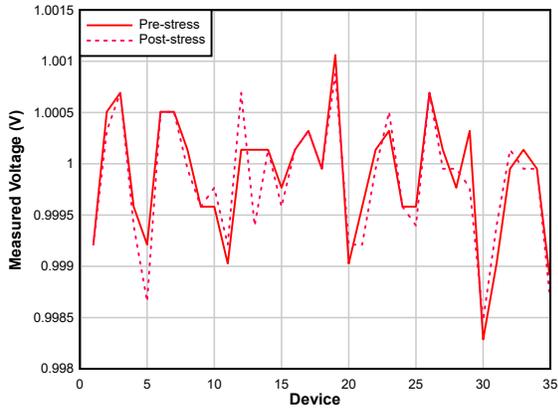


Figure 3-43. VC11-VC10 Measurement with 1-V Input

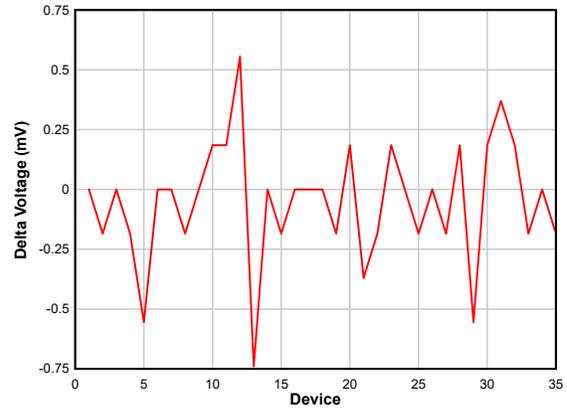


Figure 3-44. Delta in VC11-VC10 Measurements with 1-V Input

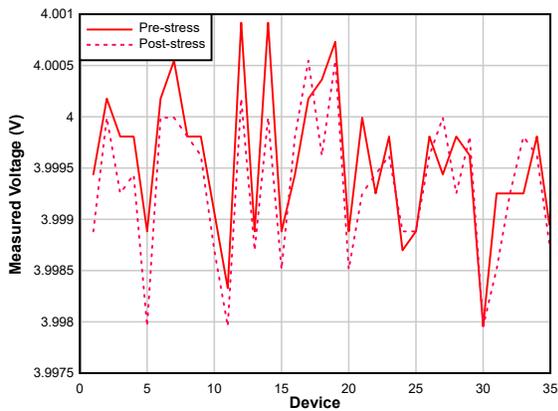


Figure 3-45. VC12-VC11 Measurement with 4-V Input

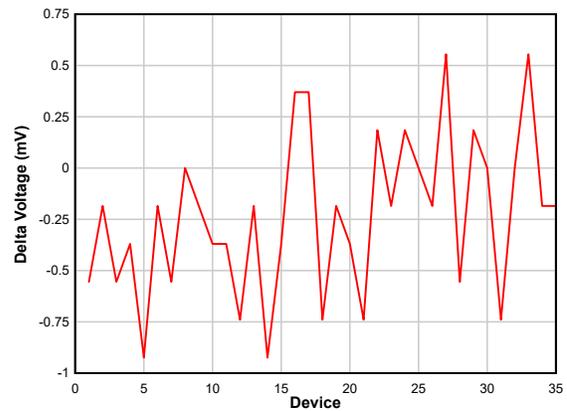


Figure 3-46. Delta in VC12-VC11 Measurements with 4-V Input

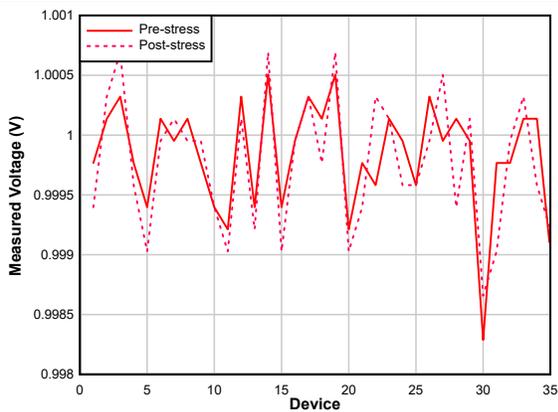


Figure 3-47. VC12-VC11 Measurement with 1-V Input

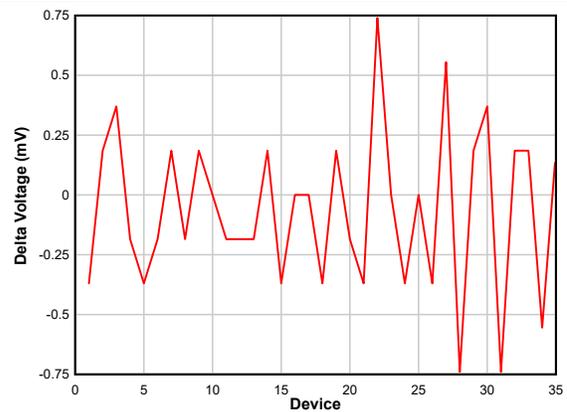


Figure 3-48. Delta in VC12-VC11 Measurements with 1-V Input

3.1 Graphical Data (continued)

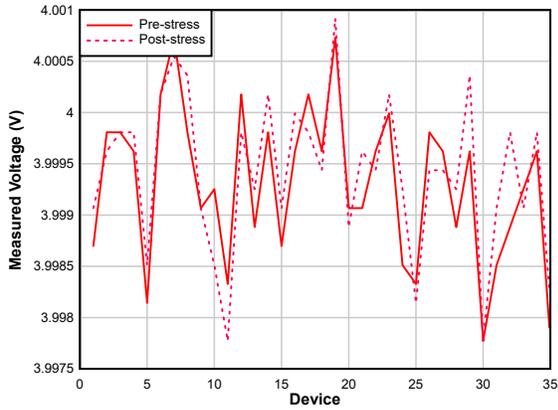


Figure 3-49. VC13-VC12 Measurement with 4-V Input

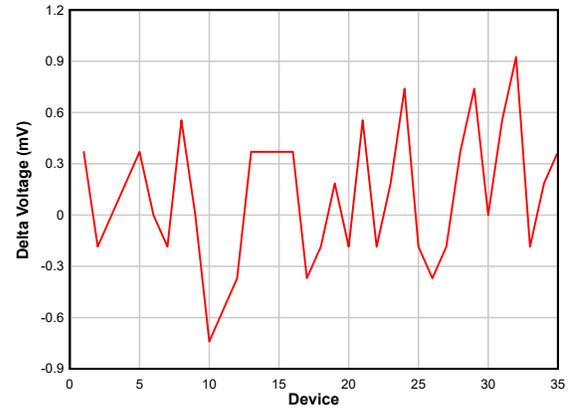


Figure 3-50. Delta in VC13-VC12 Measurements with 4-V Input

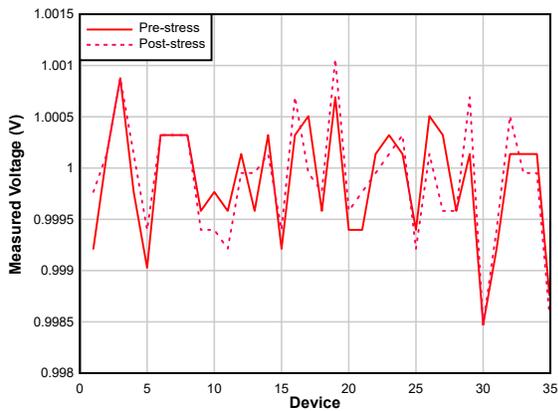


Figure 3-51. VC13-VC12 Measurement with 1-V Input

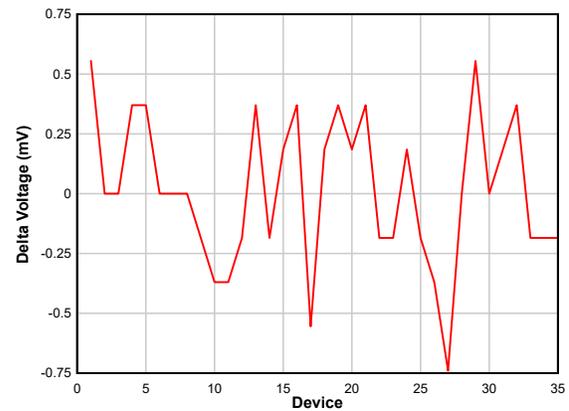


Figure 3-52. Delta in VC13-VC12 Measurements with 1-V Input

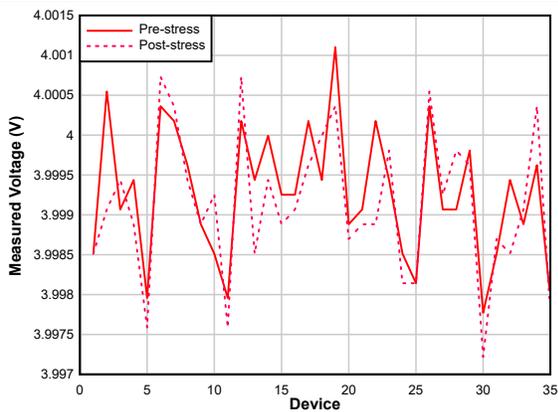


Figure 3-53. VC14-VC13 Measurement with 4-V Input

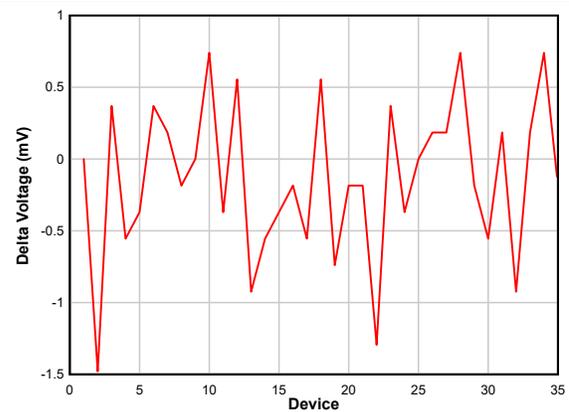


Figure 3-54. Delta in VC14-VC13 Measurements with 4-V Input

3.1 Graphical Data (continued)

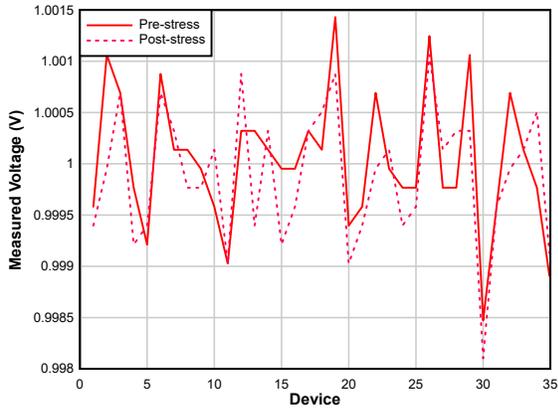


Figure 3-55. VC14-VC13 Measurement with 1-V Input

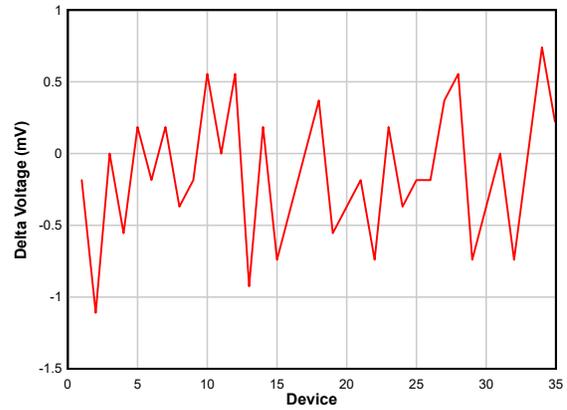


Figure 3-56. Delta in VC14-VC13 Measurements with 1-V Input

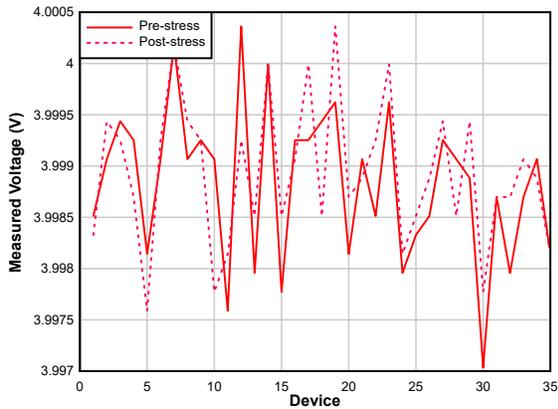


Figure 3-57. VC15-VC14 Measurement with 4-V Input

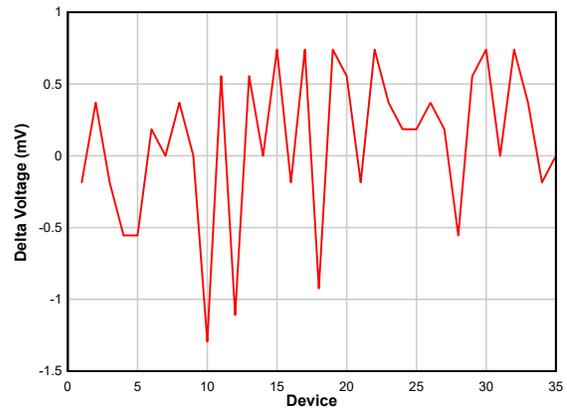


Figure 3-58. Delta in VC15-VC14 Measurements with 4-V Input

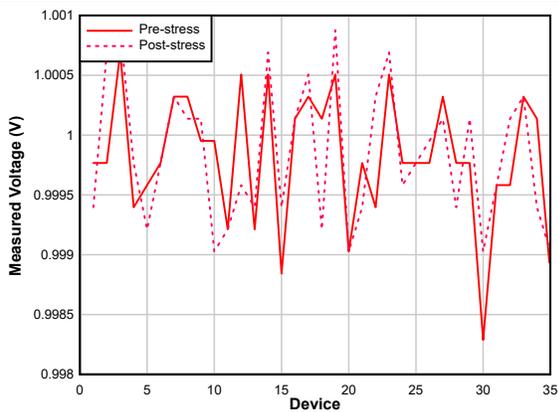


Figure 3-59. VC15-VC14 Measurement with 1-V Input

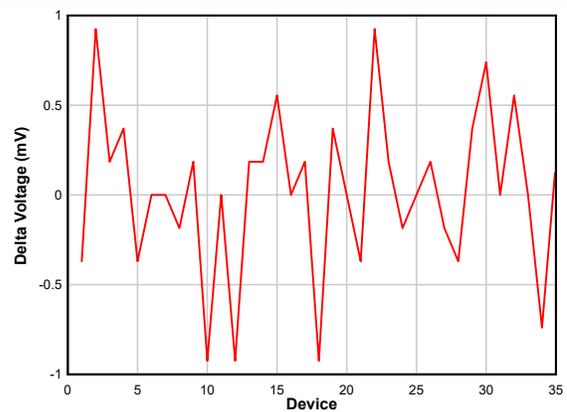


Figure 3-60. Delta in VC15-VC14 Measurements with 1-V Input

3.1 Graphical Data (continued)

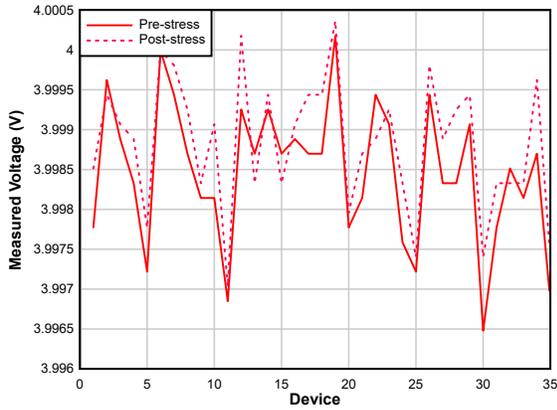


Figure 3-61. VC16-VC15 Measurement with 4-V Input

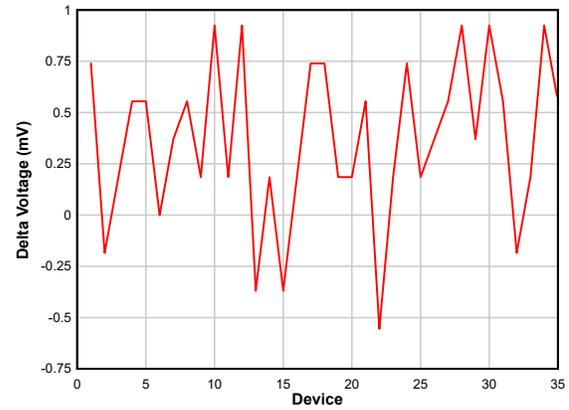


Figure 3-62. Delta in VC16-VC15 Measurements with 4-V Input

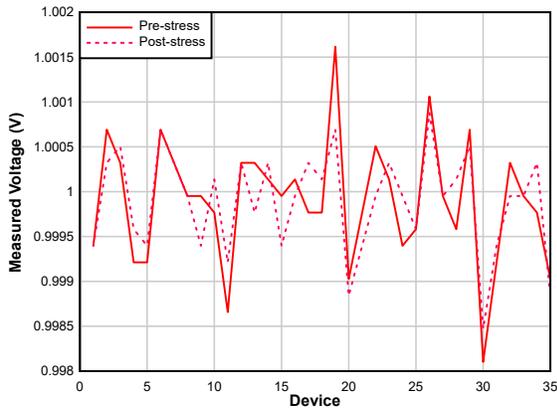


Figure 3-63. VC16-VC15 Measurement with 1-V Input

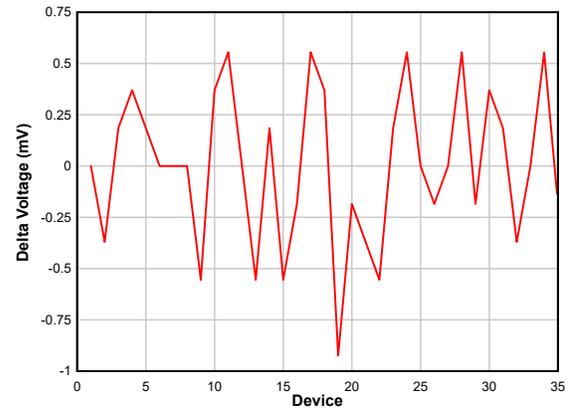


Figure 3-64. Delta in VC16-VC15 Measurements with 1-V Input

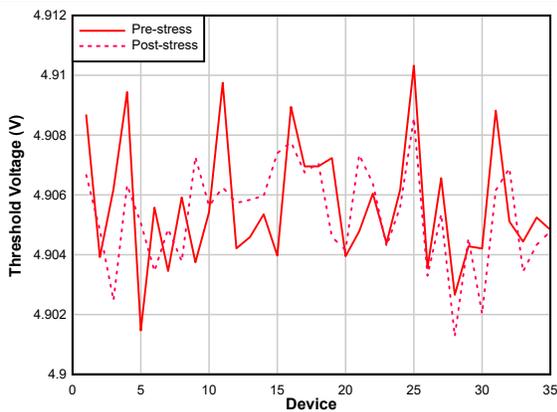


Figure 3-65. VC4-VC3 COV Threshold = 4.9082 V

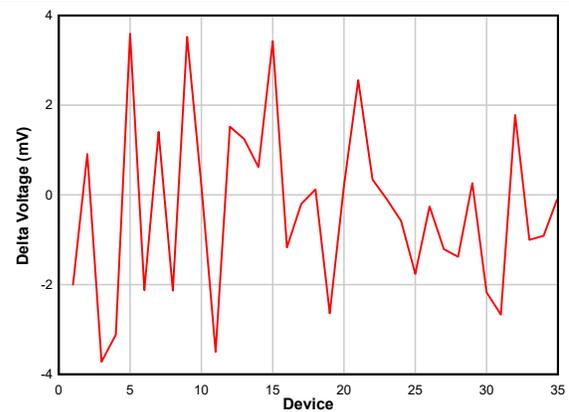


Figure 3-66. Delta in VC4-VC3 COV Threshold = 4.9082 V

3.1 Graphical Data (continued)

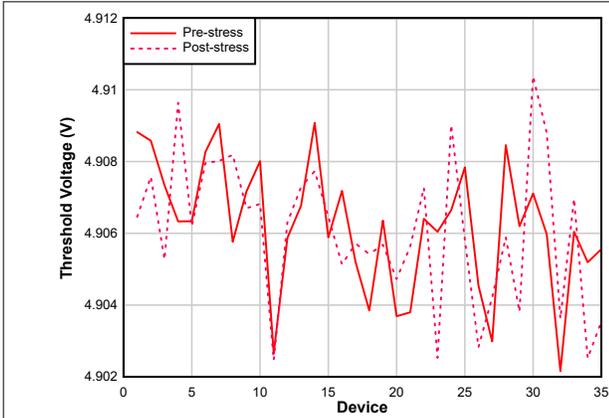


Figure 3-67. VC8-VC7 COV Threshold = 4.9082 V

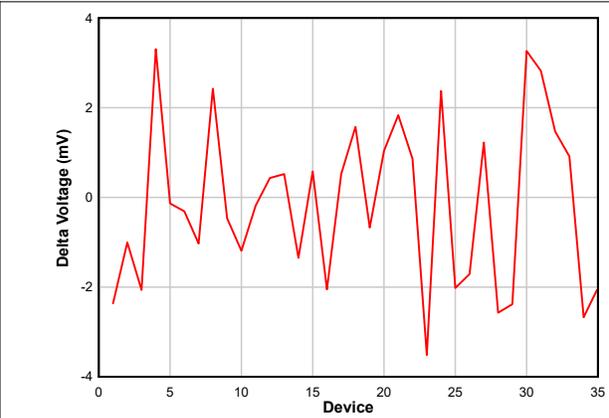


Figure 3-68. Delta in VC8-VC7 COV Threshold = 4.9082 V

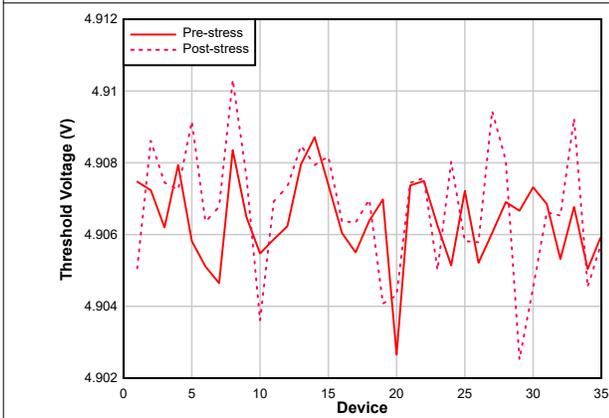


Figure 3-69. VC12-VC11 COV Threshold = 4.9082 V

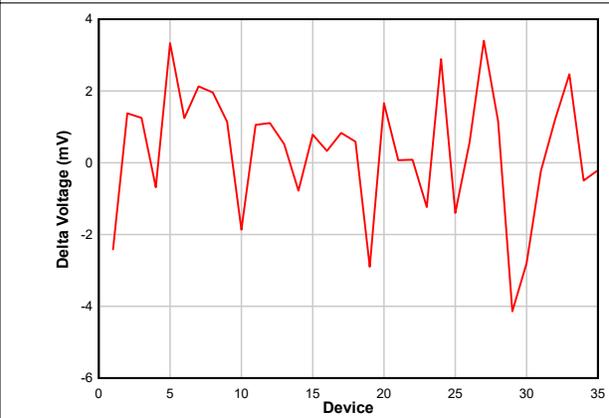


Figure 3-70. Delta in VC12-VC11 COV Threshold = 4.9082 V

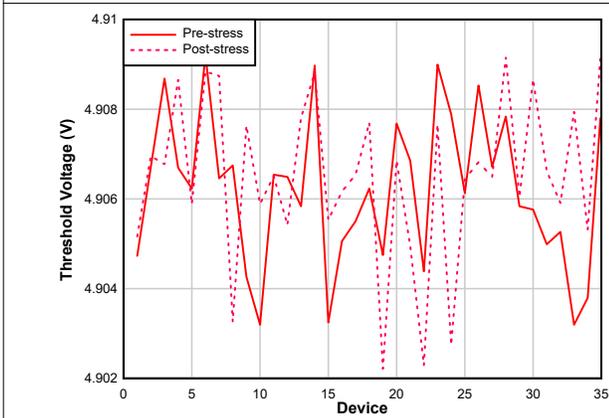


Figure 3-71. VC16-VC15 COV Threshold = 4.9082 V

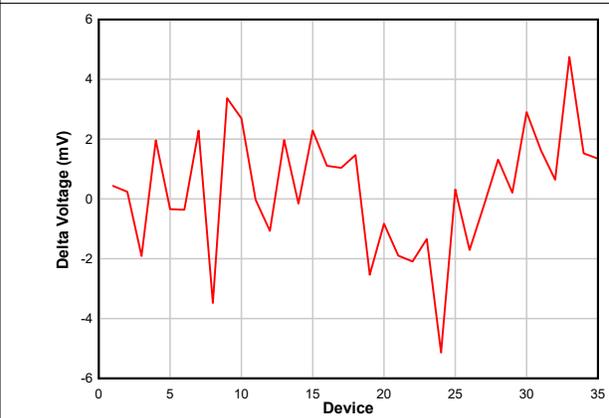


Figure 3-72. Delta in VC16-VC15 COV Threshold = 4.9082 V

3.1 Graphical Data (continued)

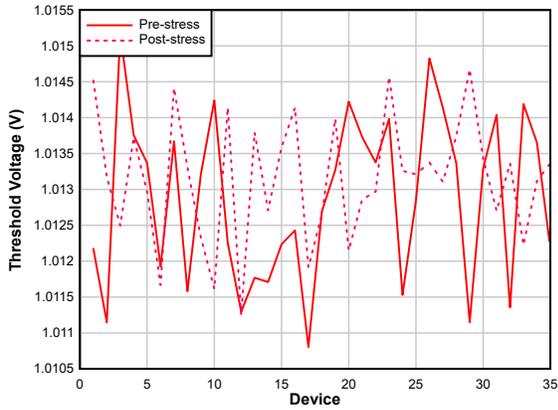


Figure 3-73. VC4-VC3 CUV Threshold = 1.012 V

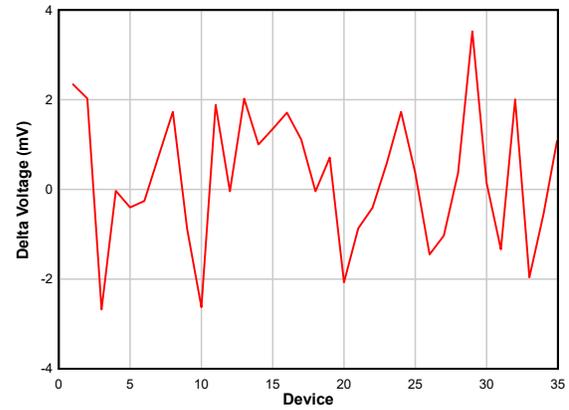


Figure 3-74. Delta in VC4-VC3 CUV Threshold = 1.012 V

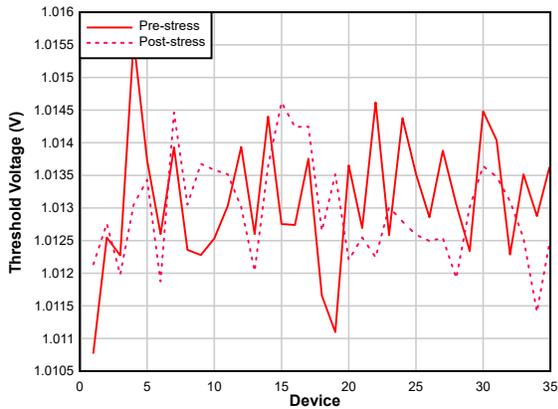


Figure 3-75. VC8-VC7 CUV Threshold = 1.012 V

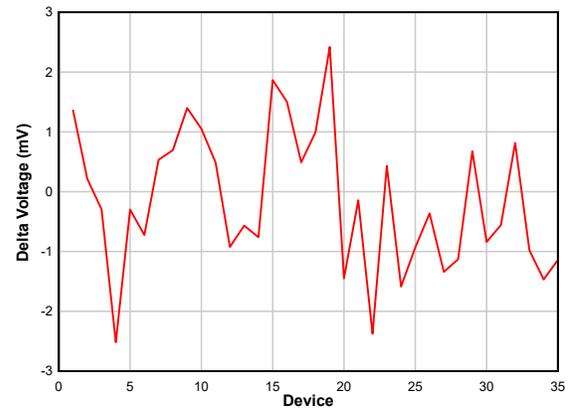


Figure 3-76. Delta in VC8-VC7 CUV Threshold = 1.012 V

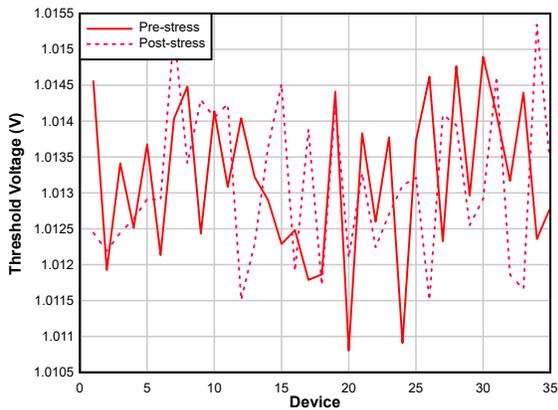


Figure 3-77. VC12-VC11 CUV Threshold = 1.012 V

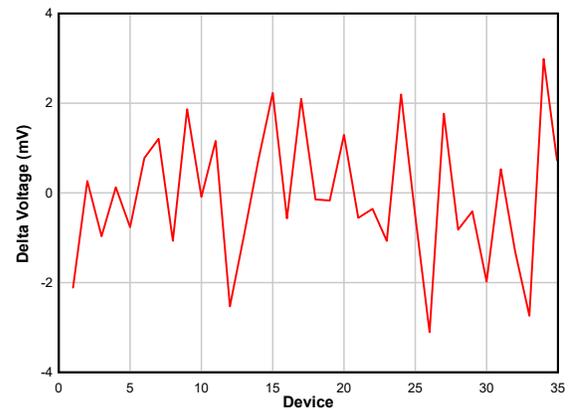


Figure 3-78. Delta in VC12-VC11 CUV Threshold = 1.012 V

3.1 Graphical Data (continued)

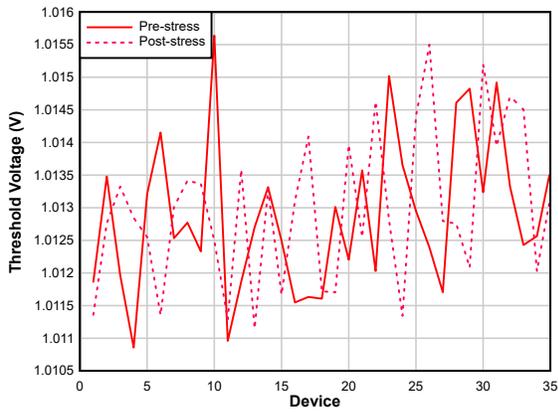


Figure 3-79. VC16-VC15 CUV Threshold = 1.012 V

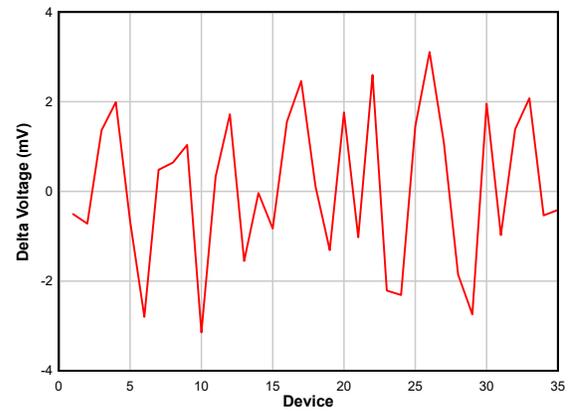


Figure 3-80. Delta in VC16-VC15 CUV Threshold = 1.012 V

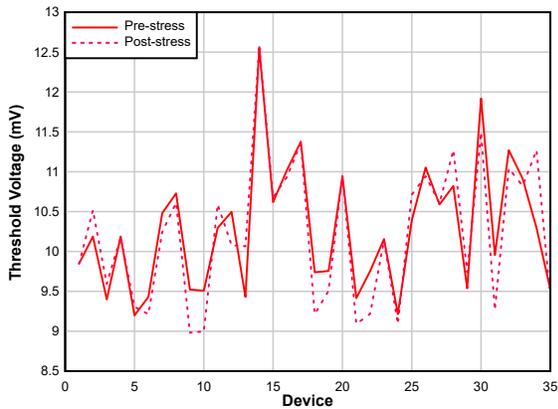


Figure 3-81. SCD Threshold = 10 mV

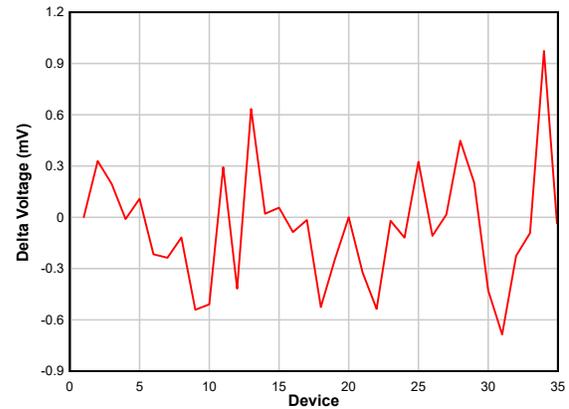


Figure 3-82. Delta in SCD Threshold = 10 mV

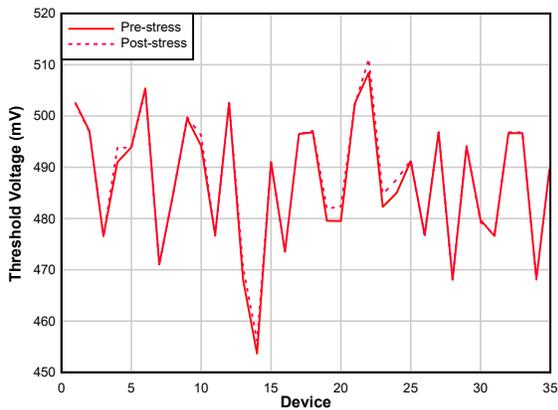


Figure 3-83. SCD Threshold = 500 mV

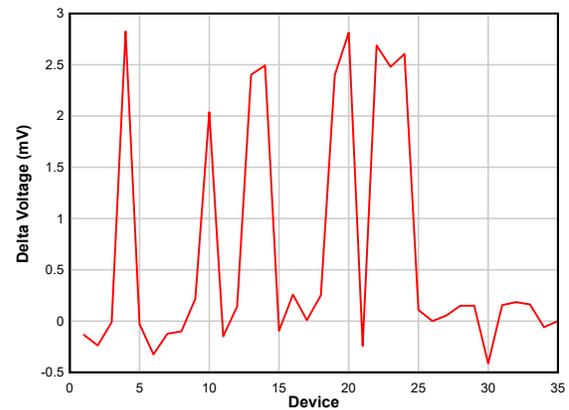


Figure 3-84. Delta in SCD Threshold = 500 mV

4 Summary

While TI cannot warranty device operation beyond specified datasheet limits, an experiment was performed to expose selected high voltage pins of set of 35 devices to a 120 V level at a temperature of 85°C. Pertinent parametric data was collected on each device before and after the stress was applied, with results and changes in parameters described by device.

In evaluating the resulting data, no systemic changes were observed pre-stress to post-stress, with errors remaining within specifications. No analysis was performed to ascertain the effect of the stress on long term device reliability. This data should **not** be interpreted to assume that all devices will exhibit similar results when exposed to similar conditions. TI recommends customers operate devices only within conditions as specified in the production datasheet.

5 References

For additional information, see the following related documents:

- [BQ76952 3S-16S Battery Monitor and Protector Data Sheet](#)
- [BQ76952 Technical Reference Manual](#)
- [BQ76952 Evaluation Module User's Guide](#)

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