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Effects of Various Module Preconditioning Procedures on CdTe Pmax Measurements

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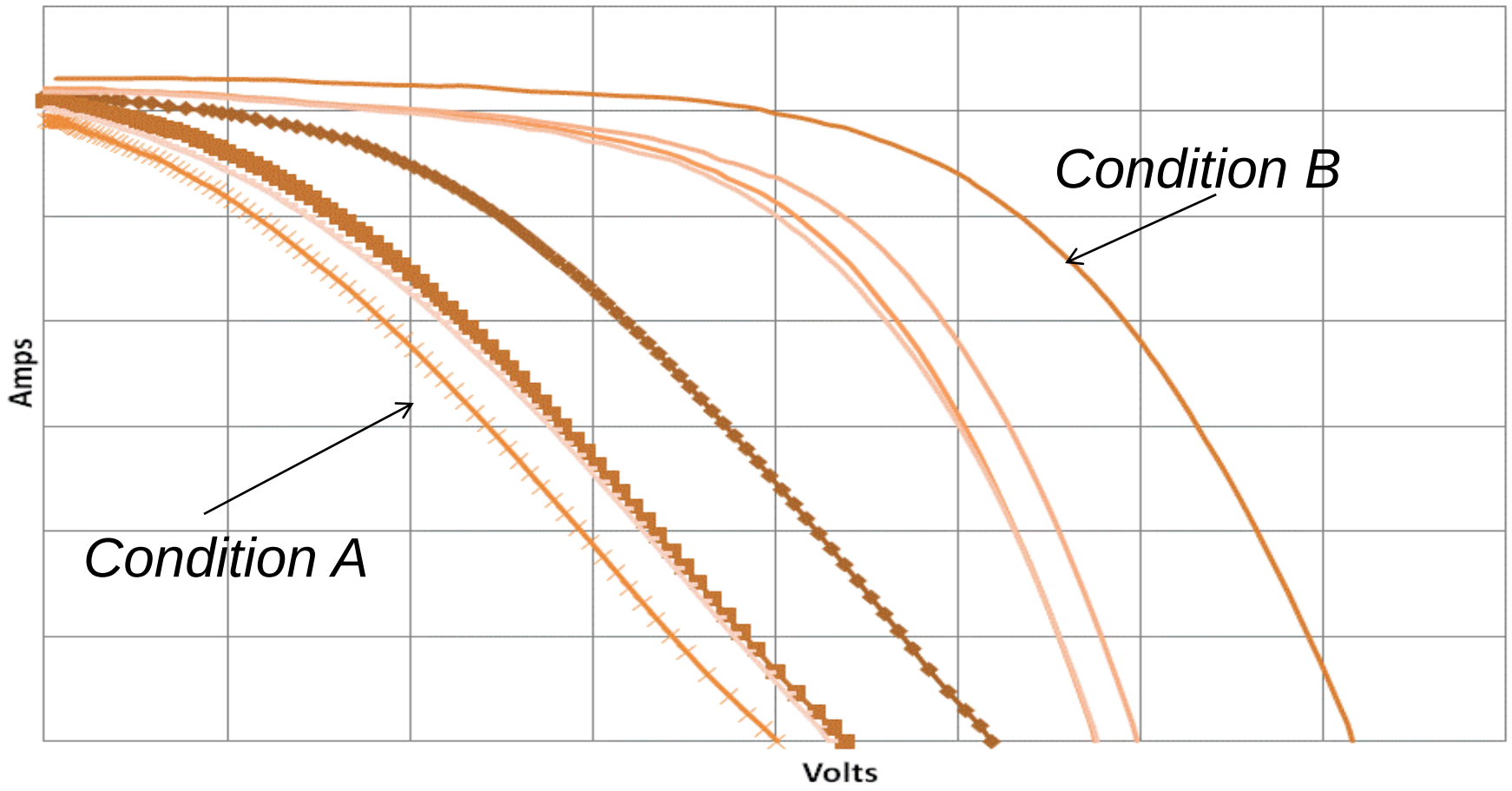
Introduction

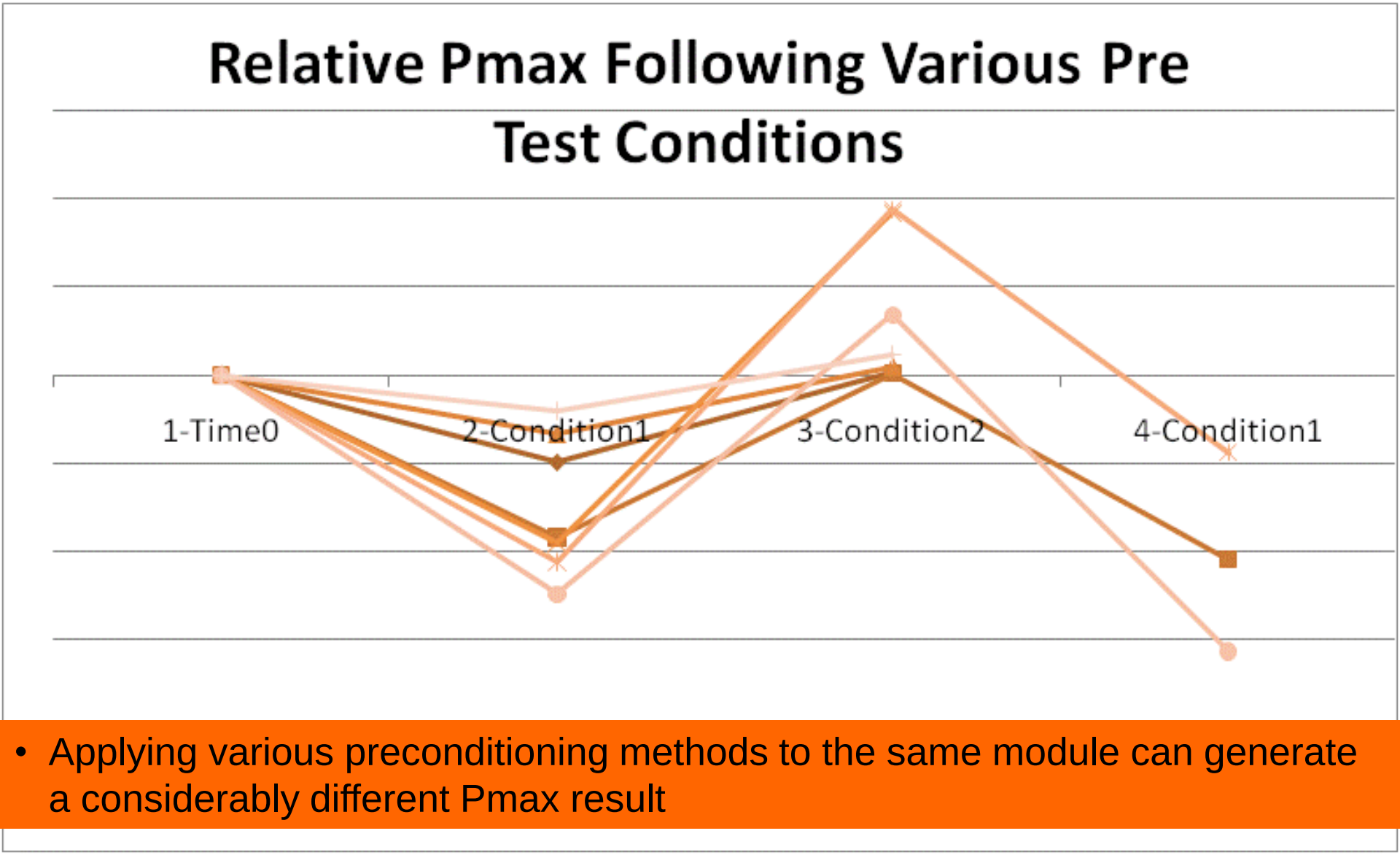
- The repeatability and accuracy of CdTe PV module Pmax measurements is significantly impacted by the condition of the module immediately prior to test
- This can create uncertainty in the results of accelerated life testing by creating unrelated drops or gains in Pmax.
- It is important to understand and characterize the impacts of preconditioning modules prior to Pmax measurements so that actual reliability trends can be identified.

Module JV Post Temp Cycling with Varying Pre-Test Conditions



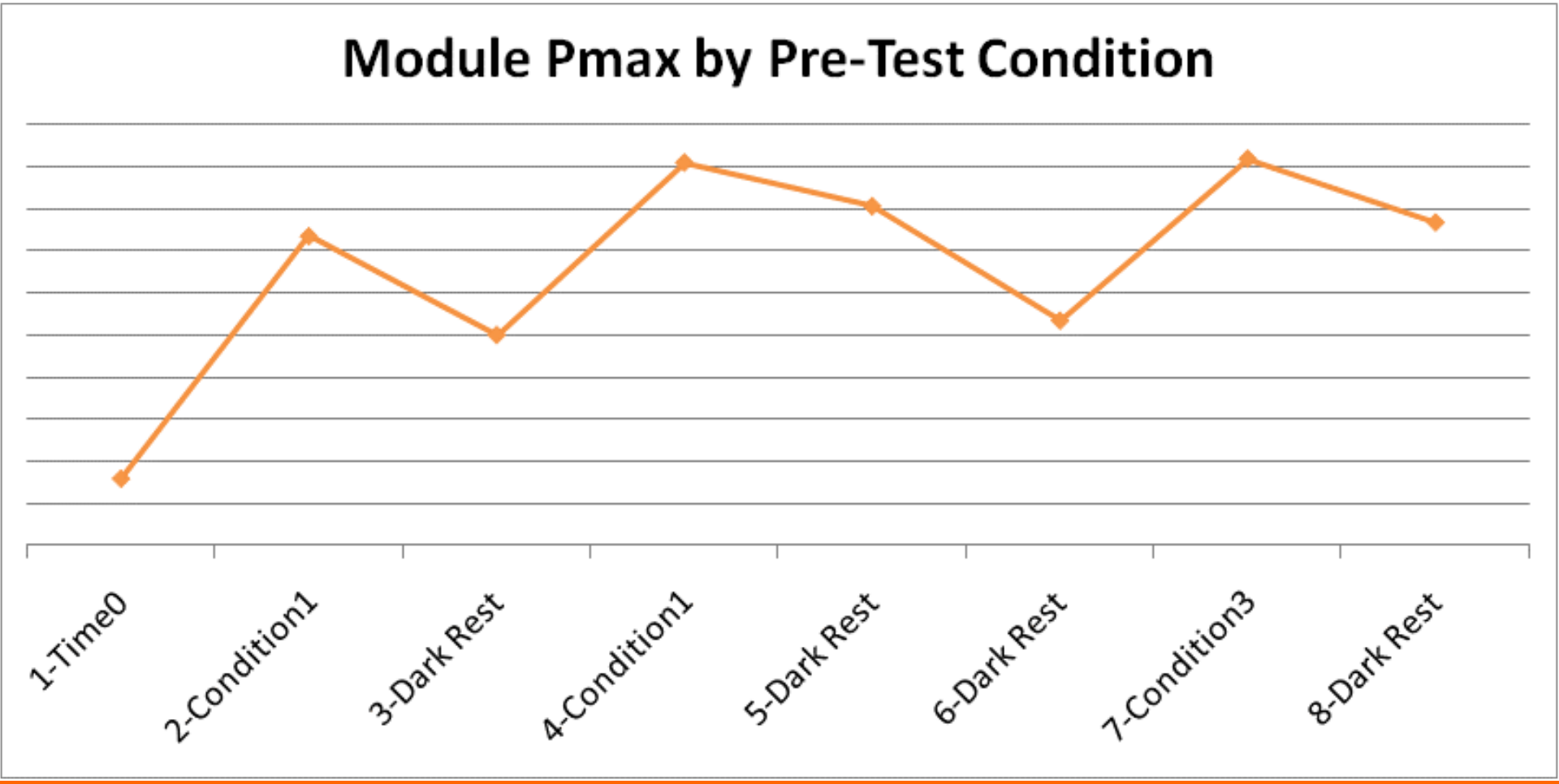
- Degradation seems to suggest a serious problem in Temperature Cycling
- However, module Pmax measurements are actually modulated by the Pre-Test Conditioning method used
- Goal is to find a Preconditioning method to match real world outdoor measurements

Pre-Test Condition vs Pmax Readout



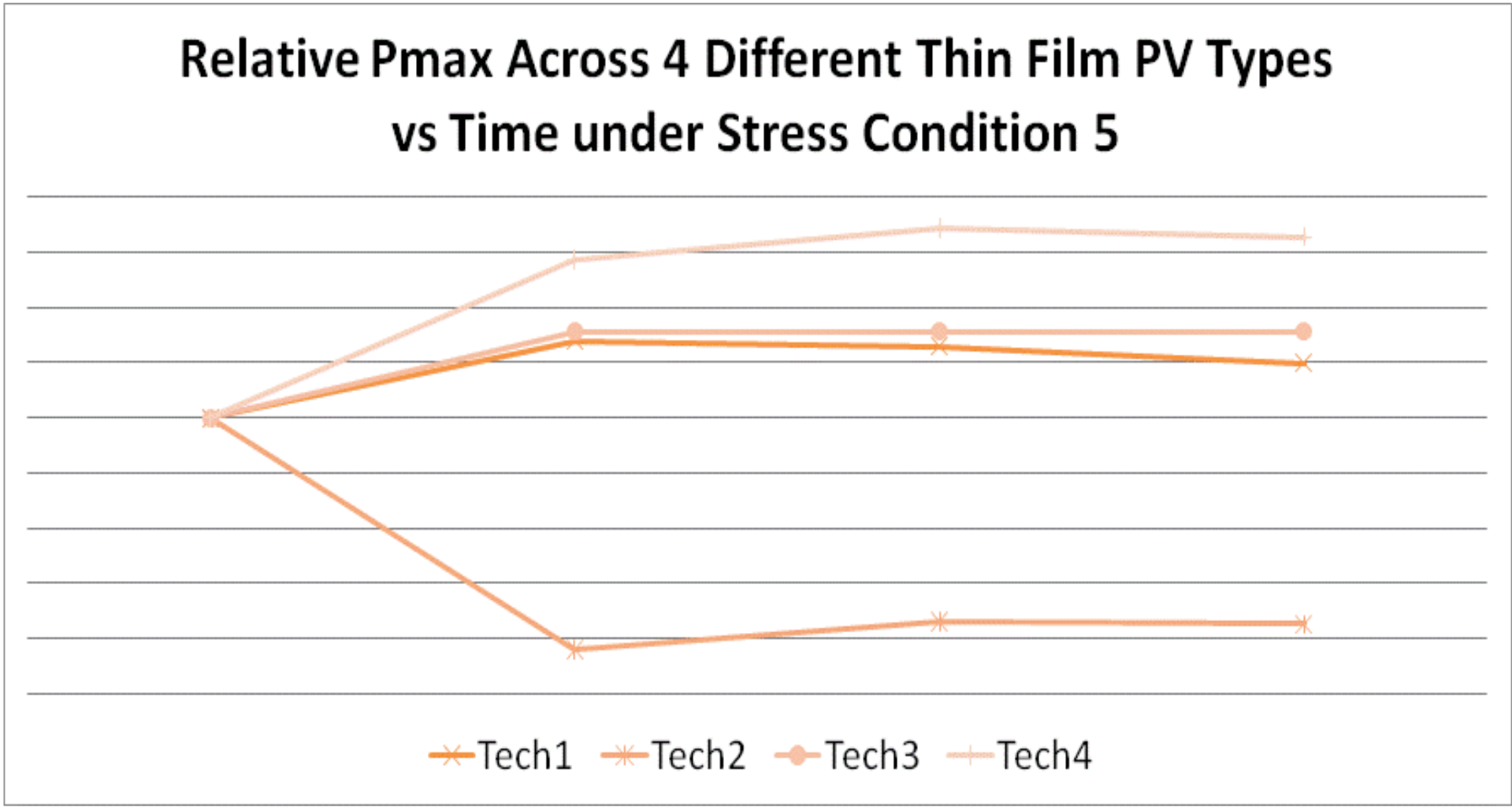
- Applying various preconditioning methods to the same module can generate a considerably different Pmax result

Pre-Test Dark Rest Impact on Pmax Readout



- Dark Rest, of varying duration, results in a dramatic decrease in the Pmax measurement

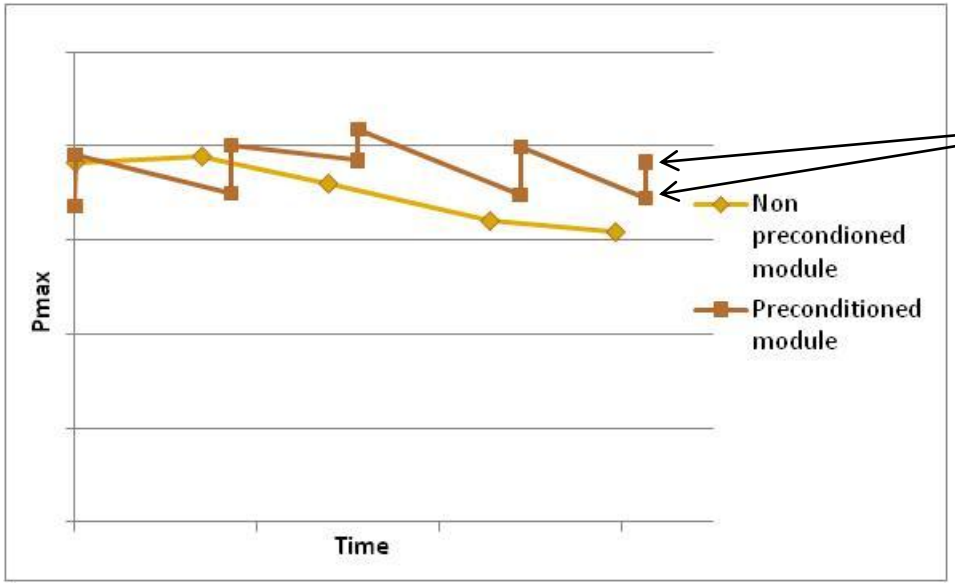
Results vary by Technology



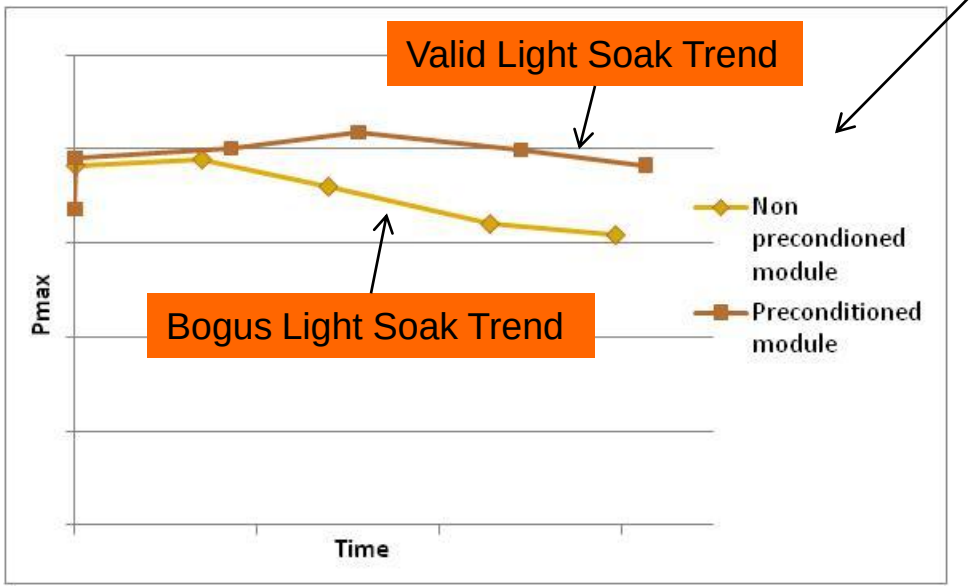
- Even subtle changes in PV technology can generate varying responses to the precondition method applied to the module prior to test.

Open Circuit Indoor Light Soak Stability

With and without Module Preconditioning



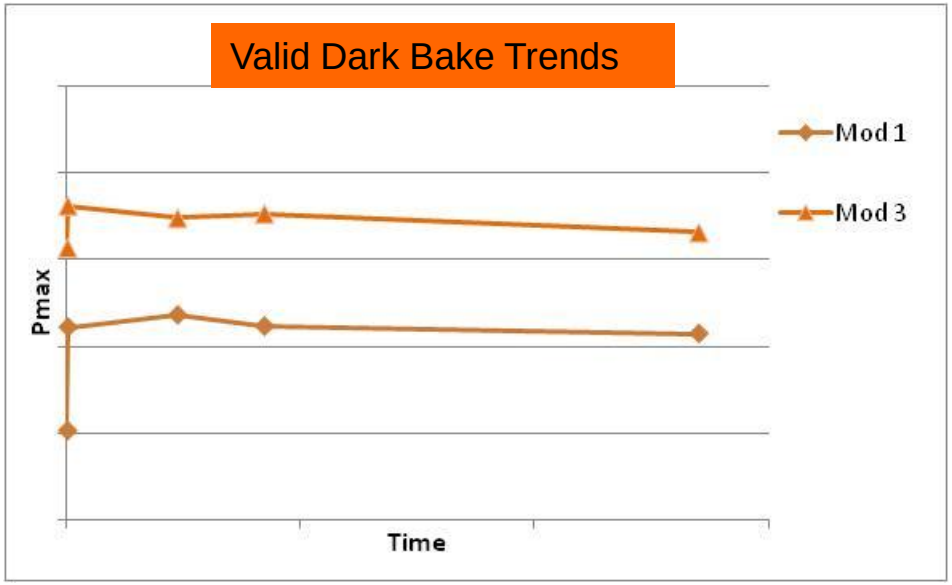
Before (lower Pmax) and After (higher Pmax) Module Preconditioning

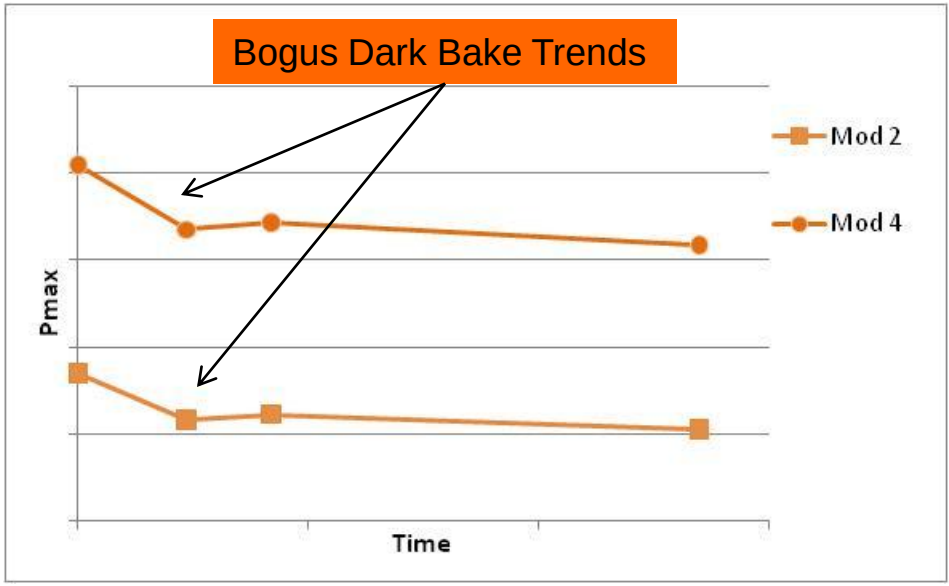


Same chart with only the post-Preconditioned Pmax measurements

- Without module Preconditioning, indoor light soak wrongly suggests module is degrading
- In reality, module is **perfectly stable**

85°C Unbiased Dark Bake Stability
with and without Module Preconditioning





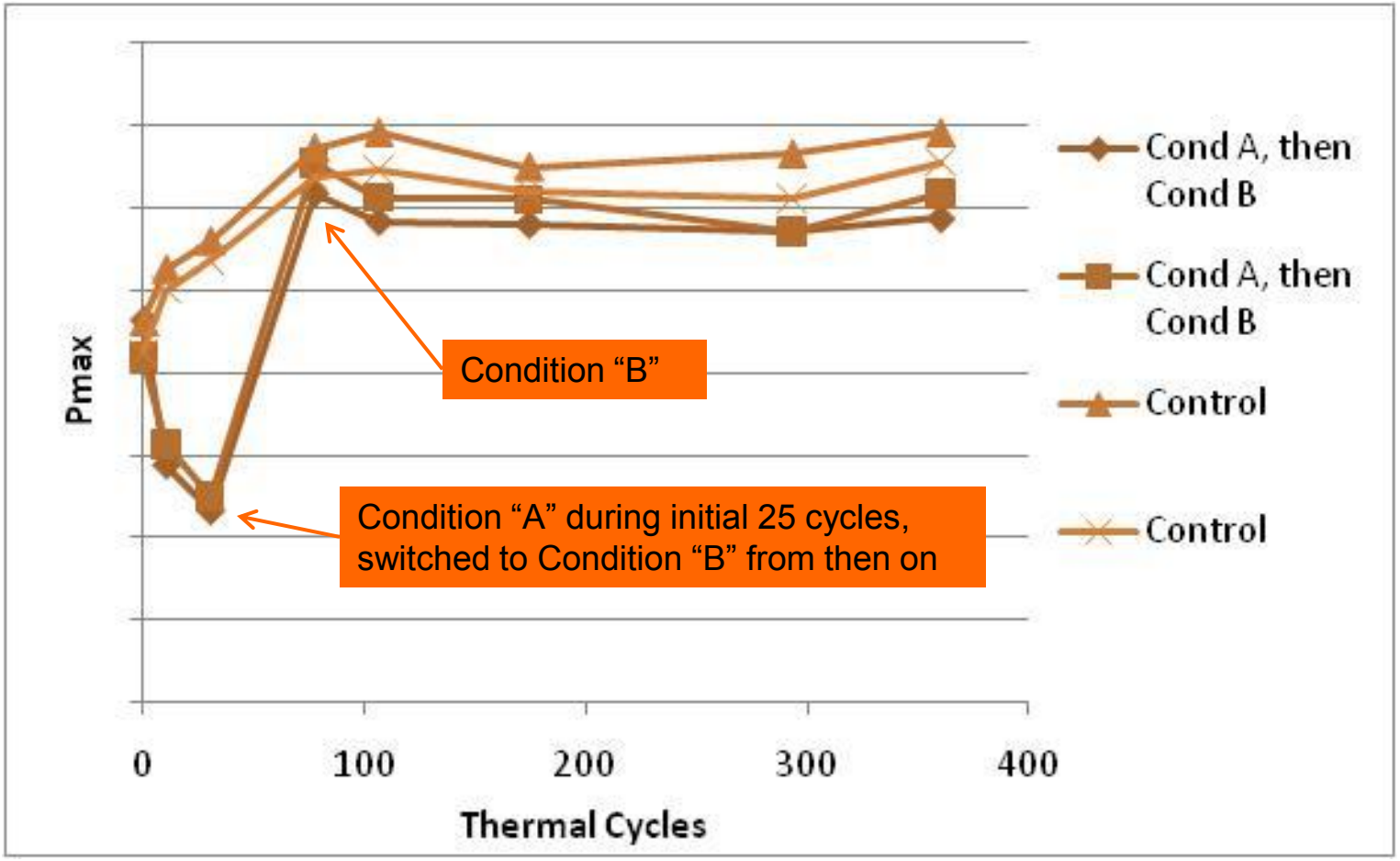
Module Preconditioning performed prior to all Pmax measurements

Module Preconditioning performed only at time zero measurement

- Without module Preconditioning at each Pmax measurement, the 85°C Dark Bake wrongly suggests modules degraded from Time Zero
- In reality, modules are **perfectly stable**

Temperature Cycle Stability

Effects with and without different module conditioning in TC



- Use of condition method "A" while in thermal cycle leads to bogus module degradation that is completely reversible with Condition method "B"
- Similar behavior seen in 85°C Dark Bake

Conclusions

- Dark storage effects on CdTe modules can be reversed through various forms of Preconditioning
- Proper Preconditioning leads to more accurate Pmax determination
- Module Preconditioning leads to more accurate reliability assessments
- There appears to be no consistent methodology used for Preconditioning PV modules in the industry
- Preconditioning effectiveness appears to vary by PV technology and must be characterized by each manufacturer