



# TestConX™

## Archive

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## Validation Platform to Characterize Standalone Oscillators in Various Package Sizes

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## OUTLINE

- Introduction
- TIs BAW Oscillator
- Importance of Validation
- Single Site vs Multi Site Test
- Different Multi Site Test Solutions
- Results
- Conclusion



Validation Platform to Characterize Standalone Oscillators in Various Package Sizes

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## INTRODUCTION

- Every complex system requires a timing and clocking subsystem for proper system functionality
- Standalone oscillators / crystals are basic building blocks
- Oscillators are available in
  - various package types
  - package size
  - pin count
  - wide range of frequencies



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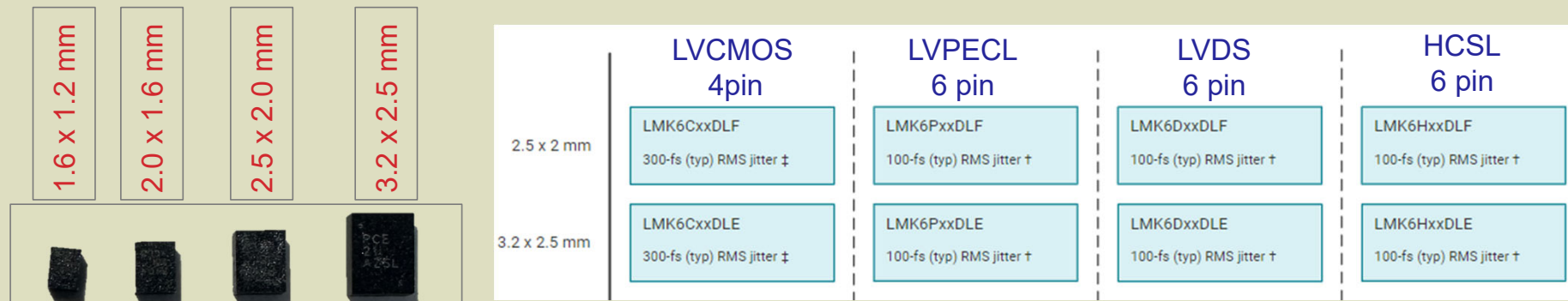
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## TIs BAW BASED OSCILLATORS

- Texas Instruments' **Bulk-Acoustic Wave (BAW)** is a micro-resonator technology that enables integration of high-precision BAW resonator directly into packages with ultra-low jitter clock circuitry
- TIs products
  - **LMK6x** – Ultra Low Jitter, Differential and Single Ended Oscillators – 2 packages – In Production
  - **CDC6C** – Low Power (5mA Active, 2uA SB) , LVCMOS Oscillators – 4 packages – Evaluation Samples
- The device is **factory programmed** per specific operation mode, including frequency, voltage, output type, and function pin.



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## IMPORTANCE OF BENCH VALIDATION

- Oscillator performance is critical to meet the timing requirement in a system
- Requires extensive characterization of all parameters across several devices to guarantee spec in datasheet
  - Jitter / Phase Noise
  - Power Consumption
  - Output Driver Time Domain Characteristics
  - Aging
  - Overall Frequency Stability across Temperature
  - Power Up Transients
  - PSRR
  - Enable / Disable Time
  - Vibration / Mechanical Shock



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## IMPORTANCE OF BENCH VALIDATION

- Limited set of parameters can get tested on ATE / Production Test
  - Test Hardware and resource constraints
  - Test Time
- Oscillators is a high volume market
  - Demands statistical data from bench (Large sample characterization)
  - Aim is to ensure quality parts are released
  - No customer returns
- In this paper we talk about **different validation platforms** used in characterizing TIs BAW oscillators and Silicon Results



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## SINGLE SITE V/S MULTI SITE TEST

- Single Site Setup for high performance and test setup dependent parameters
  - Phase Noise, PSRR, Vibration, Enable / Disable Time, Output Driver Char etc..
  - Device Count is limited to 10 to 15 units
  - Requires high end equipment (FSWP / E5052B) & passive hardware like Bias-Tee, High Z Probe for characterization
- Multi Site Setup for getting statistical data
  - Aging, Frequency stability, Final Trims, DC parameters etc..
  - Device count is ~50 to 200
  - Single Setup with higher coverage



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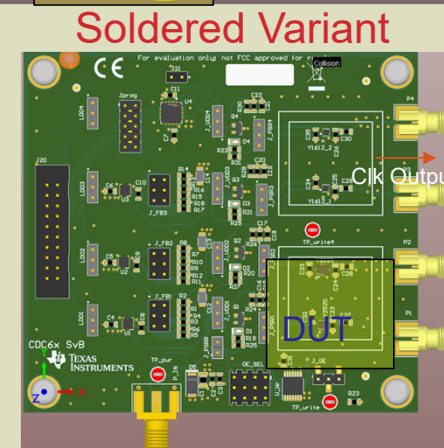
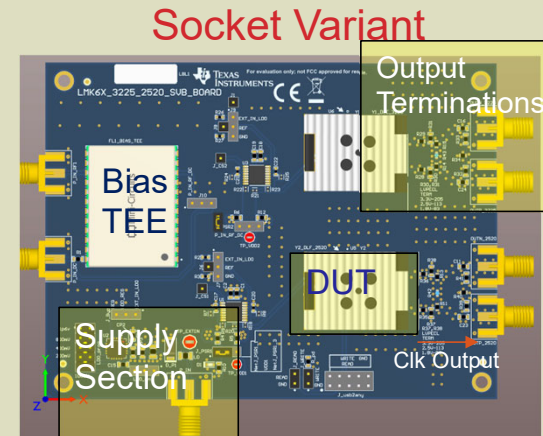




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## SINGLE SITE TEST SETUP

- Validate performance of one device at a time with precision and quality
- Clock Output lines are impedance controlled and trace lengths are short to minimize trace loss, preserve signal integrity, reduce switching current (in case of LVCMOS)
- Flexibility in testing several termination options for various output drivers



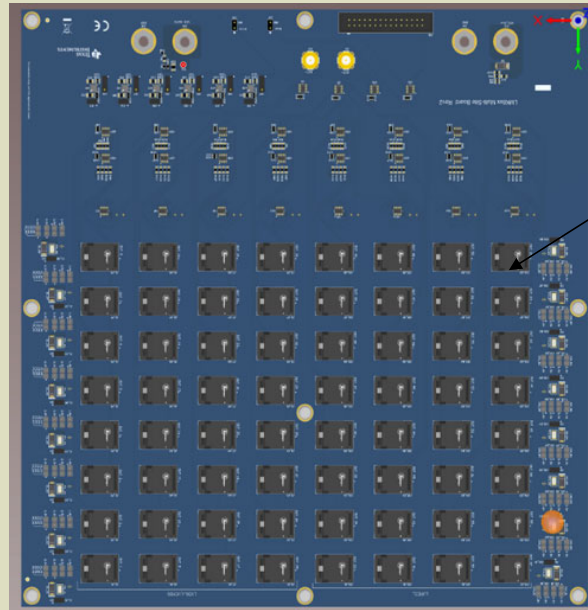
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## MULTI SITE TEST SETUP

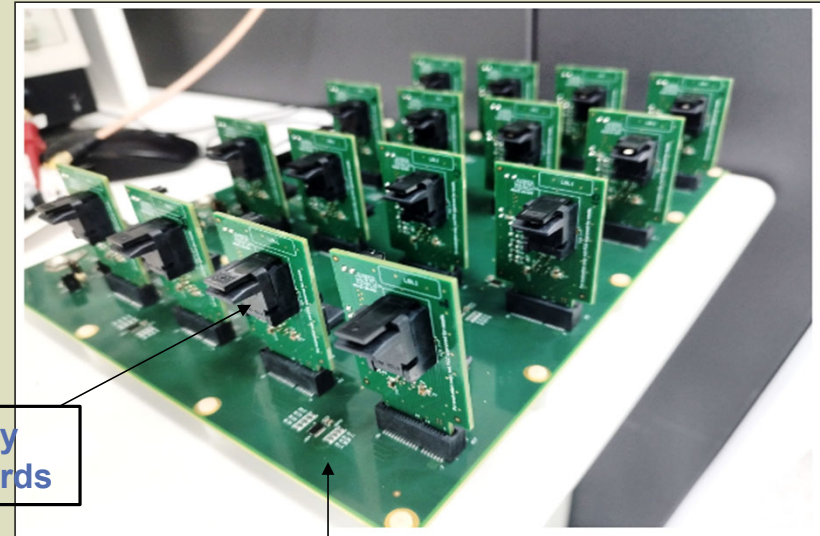
Single Package with 64 sites



64 sockets, 1 for each device

Equivalent soldered board for post solder evaluation

Mother Board + Daughter Card Setup



Plug & Play Daughter Cards

Mother Board with 16 PCIe connector sites

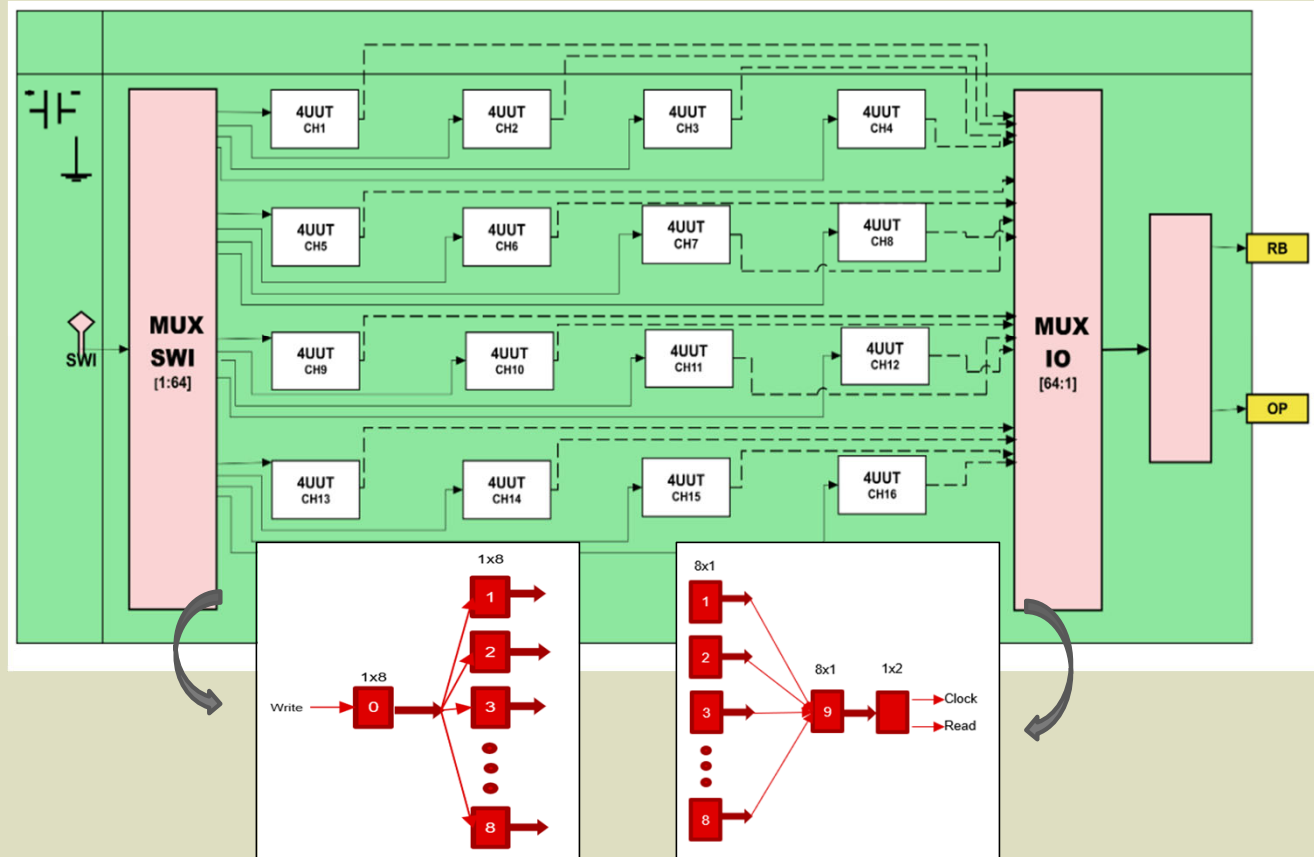


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## MULTI SITE MUX IMPLEMENTATION



- 9 MUXes for device programming
- 9 MUXes for Clock Output
- 8x1 Bi-directional Mux
- MUX Used **TI TMUX1308**
- 6 layer board with **FR-4 dielectric**
- 6 GPIO from USB2ANY used as select line controls for MUX



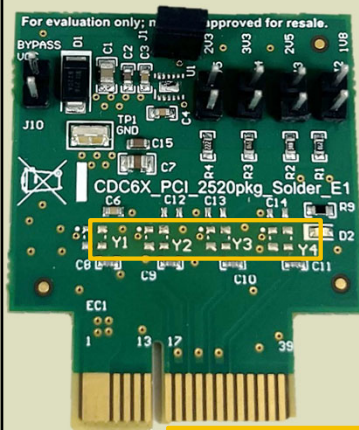
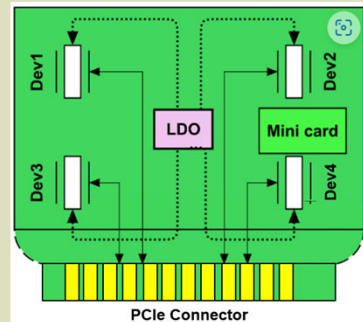
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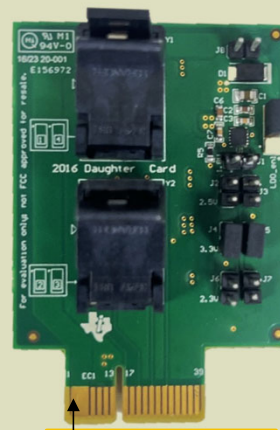


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## DAUGHTER CARD IMPLEMENTATION



Clock Out lines



Supply lines

- 2 Supply Options:
  - **LDO Mode** – Using 1 Configurable LDO to power-up 4 devices per daughter card
  - **Bypass Mode** – Directly powering-up the devices from main supply
- **4 devices** can be accommodated on the daughter card
- Soldered and Socketed version supported
- Different daughter card variants to support **4 package sizes**
  - 1.6x1.2mm , 2.0x1.6mm, 2.5x2.0mm, 3.2x2.5mm
- All Clock Out Traces are **50ohm impedance controlled**



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## ADVANTAGES OF MOTHER BOARD – DAUGHTER CARD SETUP

- Scalable and flexible:
  - Setup is flexible in handling 4 different packages at the same time + combination of soldered and socket variant of board
- Ease of Manufacturing:
  - Only manufacture Daughter cards which makes it cost efficient. Cost savings of ~48%
- Ease of Device Handling and Debug:
  - Optimize time taken to mount and remove devices from sockets
  - Debugging and probing signals become easier with daughter cards
- Reduced reflow stress:
  - Smaller daughter cards can sustain multiple solder reflows, unlike bigger boards which result in sagging thereby causing mechanical stress



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## LIMITATIONS OF MULTISITE SETUP

- Current measurement of individual devices
- Signal Integrity issues as clock path routes has a lot of via transitions / stubs
- Noise floor degradation prevents precise Jitter measurement
- Site to Site variations after multiple usage of board due to warpage, wear & tear etc.

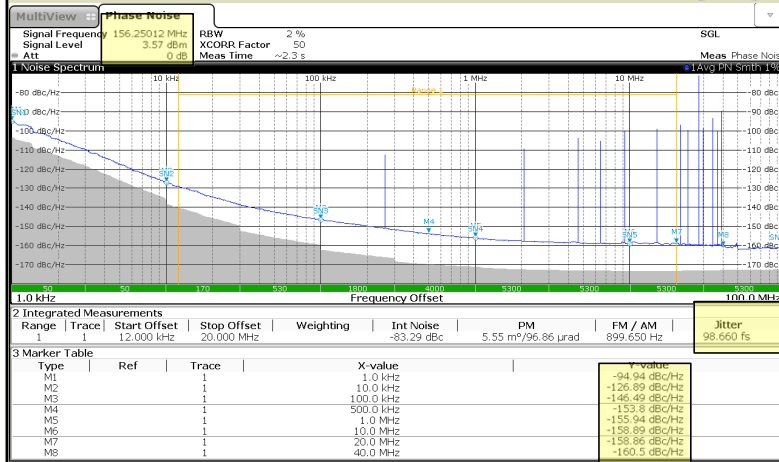


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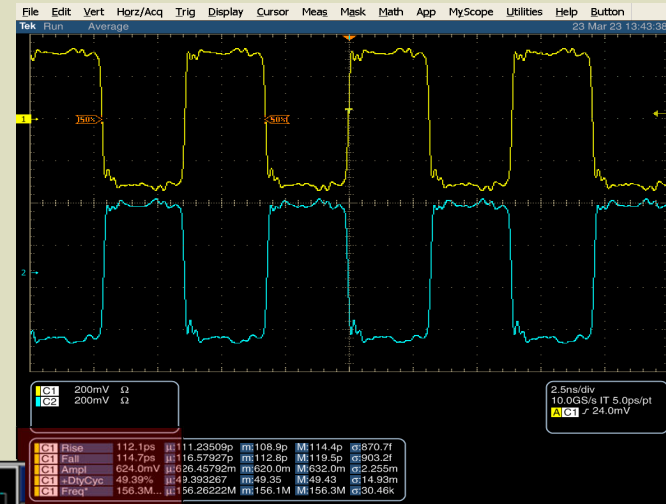
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## RESULTS – SINGLE SITE

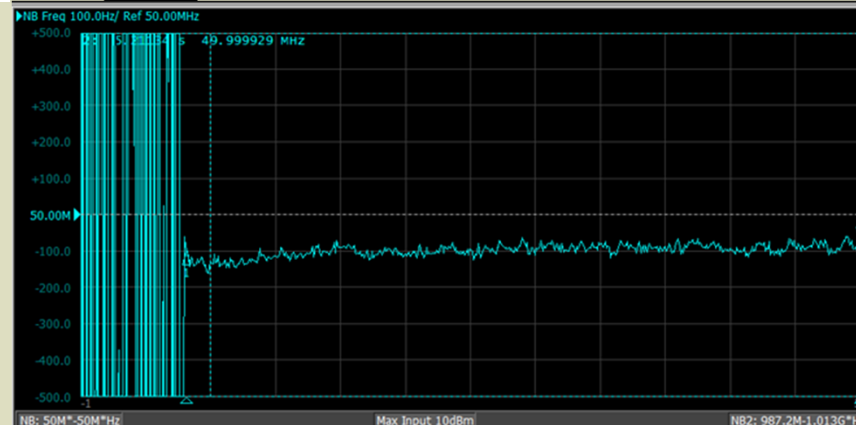


Frequency Transients



Output Driver Time Domain characteristics

Jitter Measurement for differential clock output



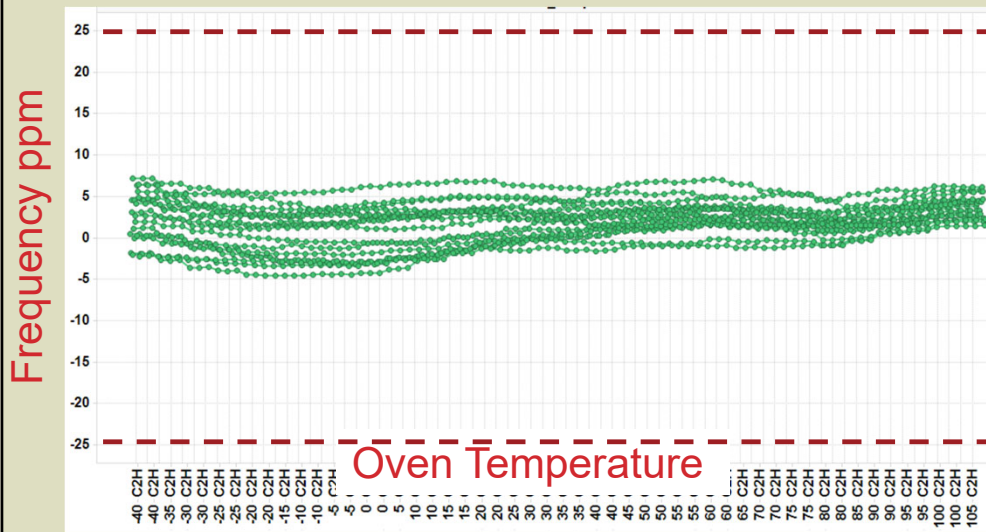
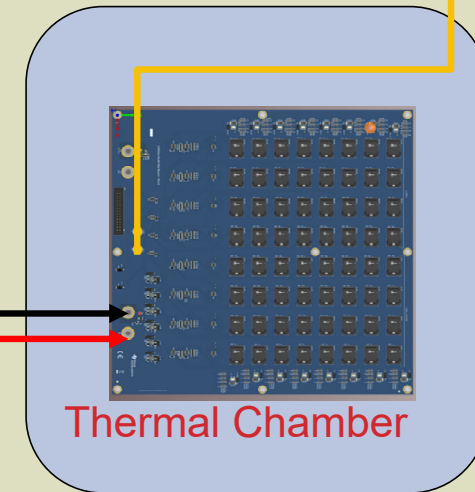
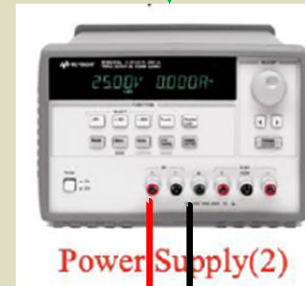
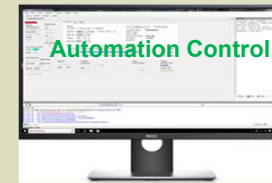
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## RESULTS : FREQUENCY STABILITY

- Measure output frequency (in terms of ppm) across multiple devices and sweeping temperature from -40 to 105 in fine steps

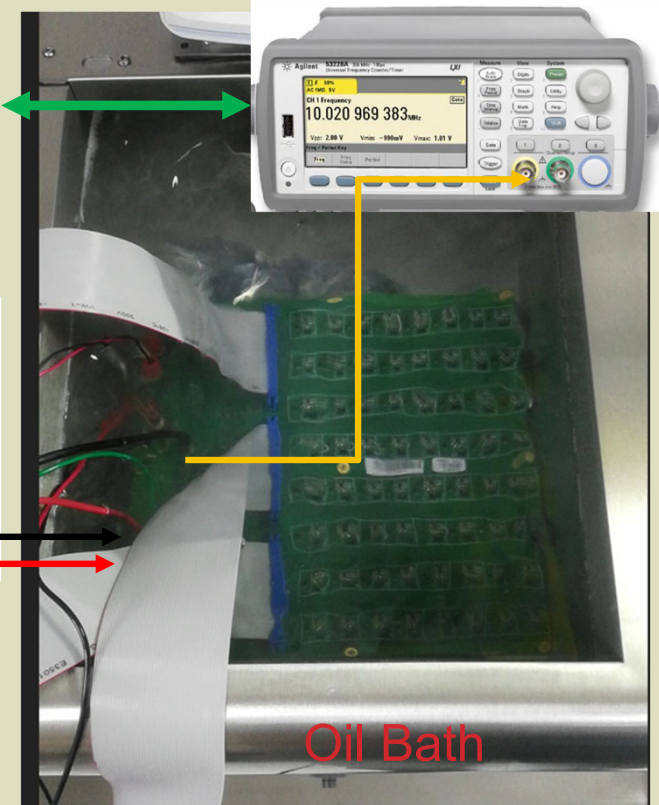
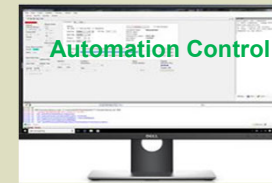
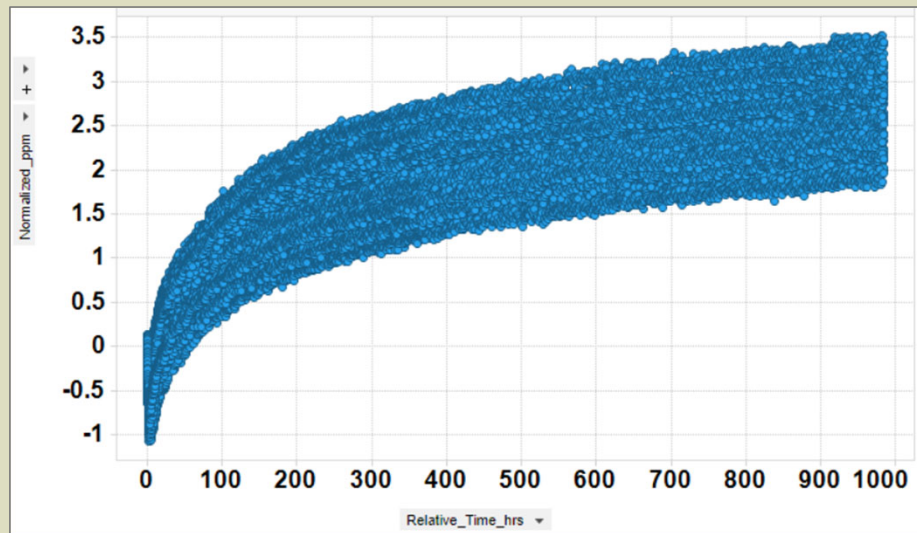


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## RESULTS : AGING SETUP

- Setup depicting Aging measurements done on multiples devices (64) in one go

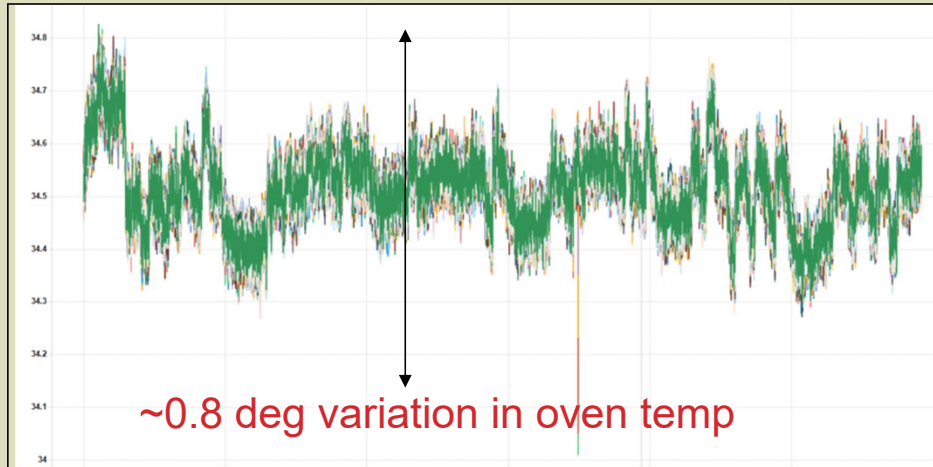


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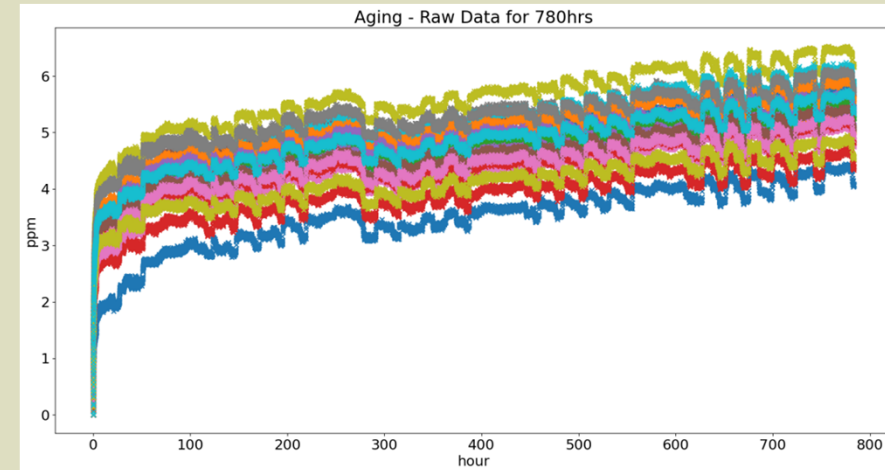
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## IMPACT ON AGING DATA WITH OVEN



Oven Temperature Variation



Impact of Oven temperature variations on frequency stability

- Temperature Chamber has inherent variation of  $\sim 0.8$ deg. Observed temperature control is sensitive to change in ambient.
- Frequency ppm variations in oven correlates with the temperature variations
- Recommended setup for Aging: Oil Bath since temperature variations are controlled



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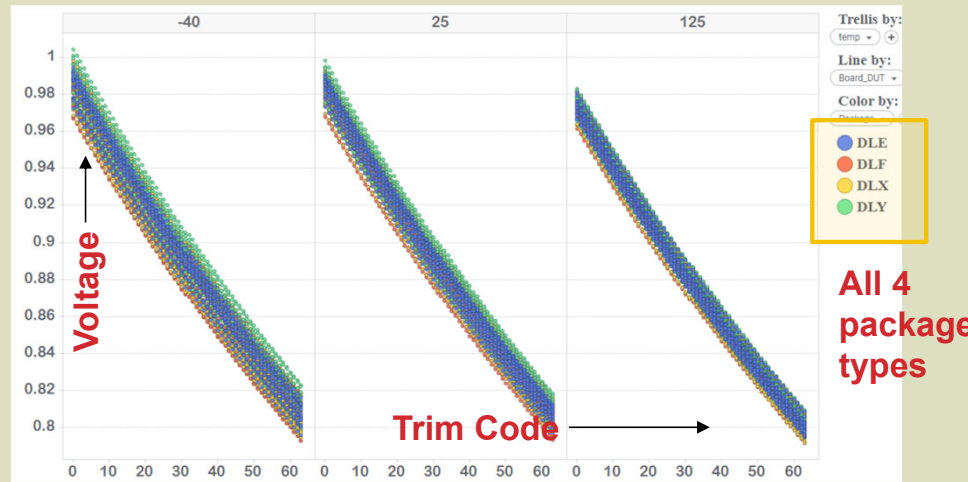
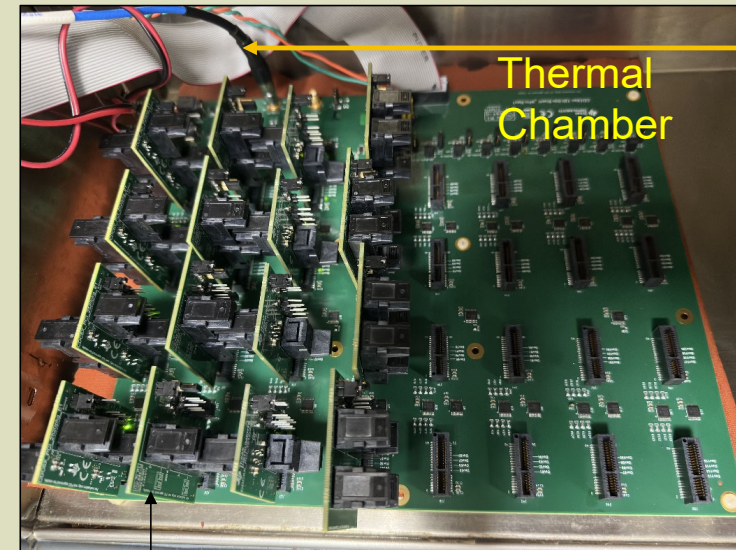
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## RESULTS : DC PARAMETERS

- Setup depicting DC measurements across 4 different package types
- Entire Mother Board+ D Card is placed in a Thermal Chamber and 64 units tested sequentially across Temperature



Daughter Cards  
4 of each package.  
16 units per package  
64 units in total



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## CONCLUSION

- In this paper, we present to you TIs BAW Based Oscillators and bench validation platform to characterize the same
  - High Performance Oscillators
  - Low Power Oscillators
- We discuss the critical aspects of bench validation and how to guarantee datasheet spec by characterization through extensive coverage
- Single Site and Multi Site Test Setups are needed to cover different types of parameters, some being performance oriented and some are statistical in nature
- Results of various parameters measured with different setups are shown



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