Ultra Low Noise Probing for Parametric and RF Testing

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Outline

> Overview
> The inherent difficulty
> Prober requirements
> Test procedure
> Results and analysis
> Conclusions and discussion

The Need for Low Noise Probing

- Improved sensitivity and precision in parametric tests
  - Current measurements
  - Resistance measurements
  - Capacitance measurements
  - Oxide thickness
- Reduced settling time
  - Greater test cell throughput

The Magnitude of the Problem

- Threshold effects
- Impact of noise on sensitivity of test
  - Gate oxide thickness is a critical DRAM parameter
  - DRAMs fail when gate oxide is too leaky
  - Stress induced leakage current limits the reduction of oxide thickness
  - Sub threshold measurement capability is an enabling technology

The Inherent Difficulty

- Current

  1 A = 1 cb/sec
- Femtoamp

  $1\ fA = 1x10^{-15}\ cb/sec \times 1\ e/1.6x10^{-19}\ cb = 6250\ e/sec$
- Thermal noise
  - Dark/leakage current is typically rated in the nA - pA range
  - Increases with temperature
- We are looking to accelerate tests by testing at elevated temperatures
  - 85-200°C

Device test requirements

- In-line parametric test
  - High throughput test cell
    - Low capacitance chuck
    - Fast settling time – get in the range to make measurement
  - Low noise environment for small test structures
    - 1990's - 100µm test structure ~ 1000pA range
    - Today - 10µm test structure ~ 200fA range
- Basic transistor measurements
- Oxide thickness
  - Low capacitance
- Tests performed at multiple temperatures

Prober Requirements

- Chuck Leakage Current plus Noise
  - <100fA with thermal equipment off
  - <250fA with equipment running
- Chuck Residual Capacitance
  - <500pF
- Thermal system
  - -50° C to +150°C
  - Most parametric testing well within this range

Standard Test Setup

- Agilent 4156B and 4|200e prober
- Common ground between 4156B and prober
- Chuck top positioned at probe center
- 4156B Kelvin cable connected to triax connector of the prober ISO relay box
- Ring carrier opening covered with grounded piece
- Measurements made at ambient
- Measurements made three times and results are averaged

Additional Tests with Chiller/Heater Unit

> Kelvin cable connector will be connected at multiple locations to trace signal path
> Tests will be run at multiple temperatures with Chiller/Heater unit connected

HP4156B

> High Resolution Source Monitor Unit HRSMU that extends capability to
  > 1fA resolution
  > 20fA basic accuracy
> Kelvin cable connection to remove lead resistance

Test Procedure

- > 4156B Box Only
- > 4156B and Kelvin Cables
- > 4156B Kelvin Cable ISO box
- > 4156B Kelvin Cable ISO box Triaxial cables
- > 4156B Kelvin Cable ISO box Triaxial cables Chuck Connected
- > 4156B Kelvin Cable ISO box Chuck Connected, with Chiller set to 30 degree C
- > 4156B Kelvin Cable ISO box Chuck Connected, with Chiller set to 200 degree C

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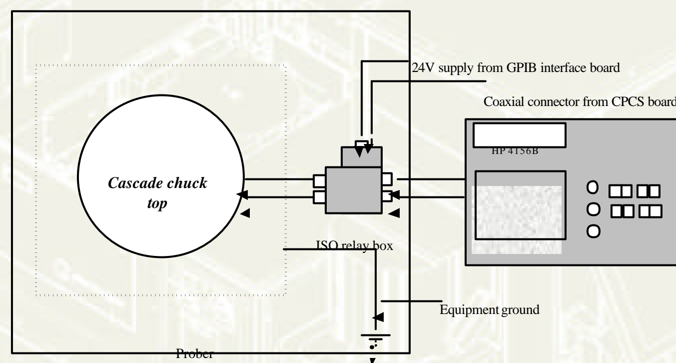
Signal Path



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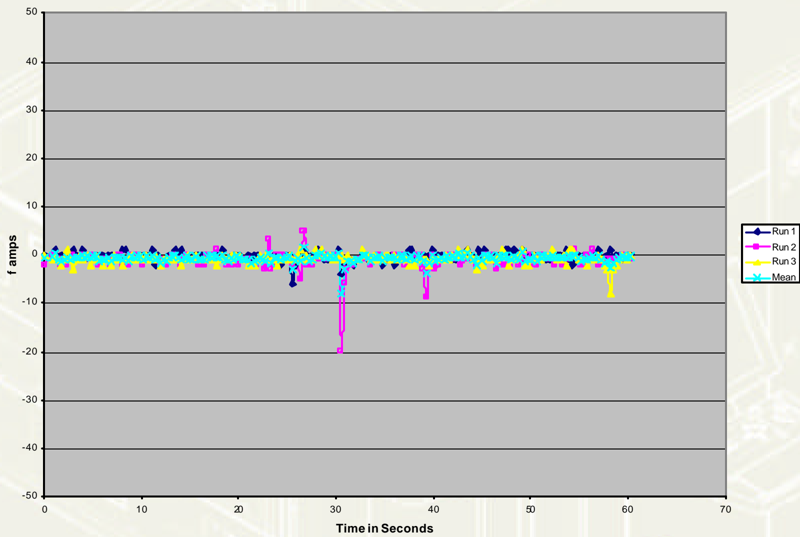
Measurement Results

The results will show that the prober measured has an experimentally demonstrated system electrical noise level of:

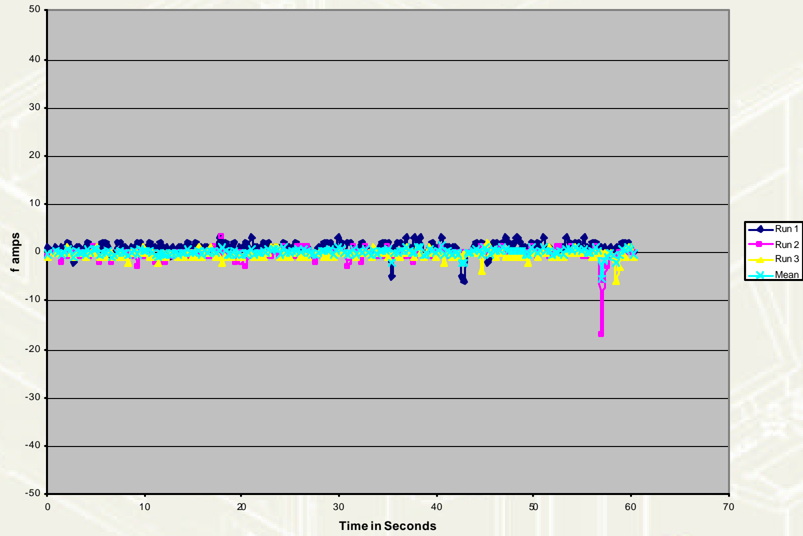
<± 30fA at Ambient

<± 250fA at 200Dergee C

4156B Tester Only



4156B and Kelvin Cables



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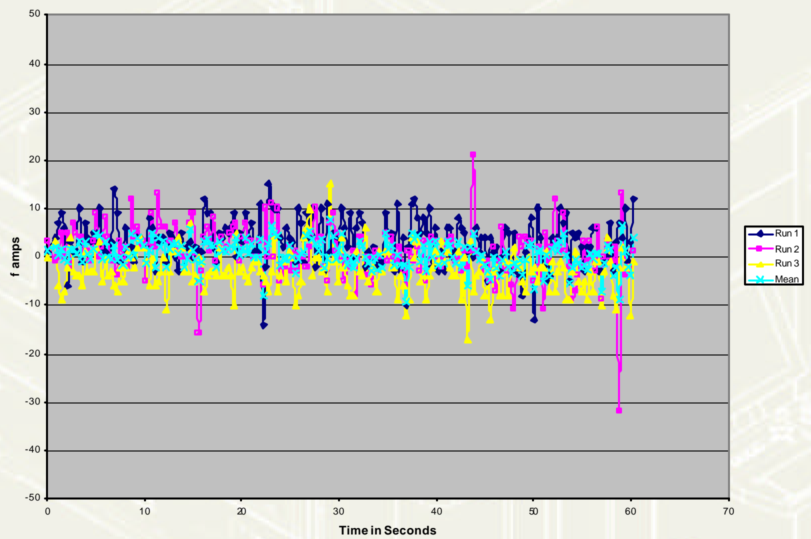
4156B Kelvin Cable ISO Box



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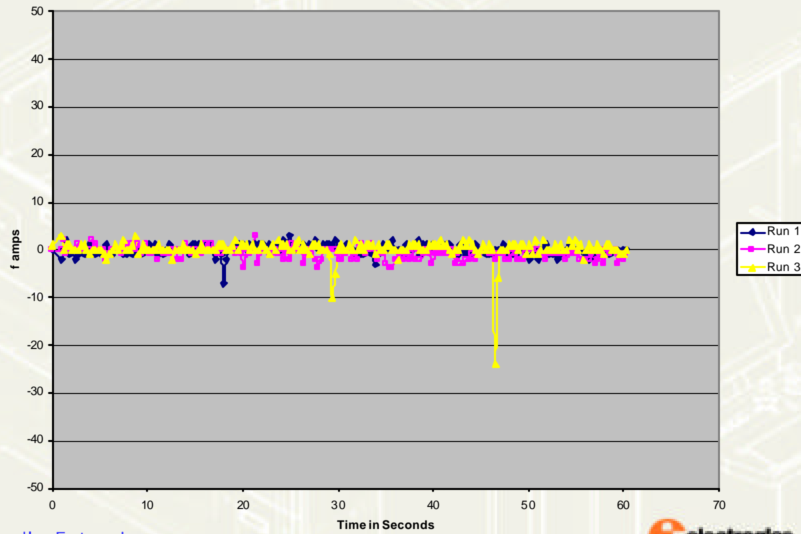
4156B Kelvin Cable ISO Box Triaxial Cables



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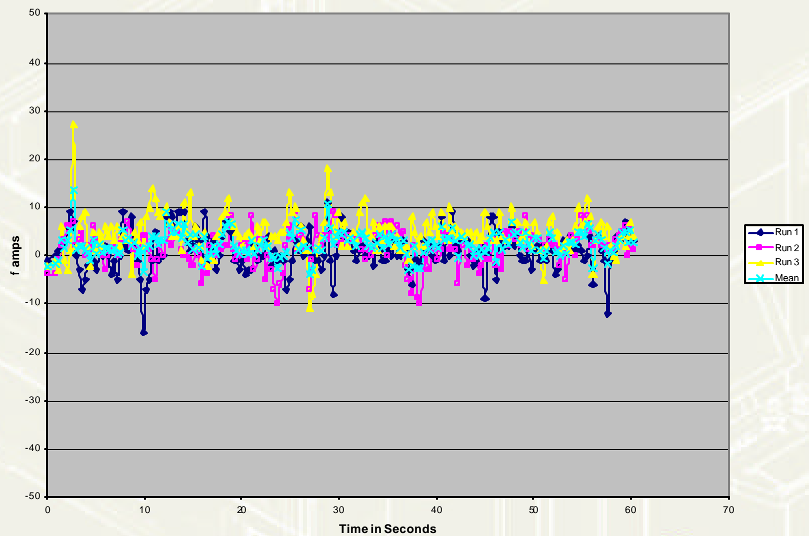
4156B Kelvin Cable ISO box Triaxial cables Chuck Connected



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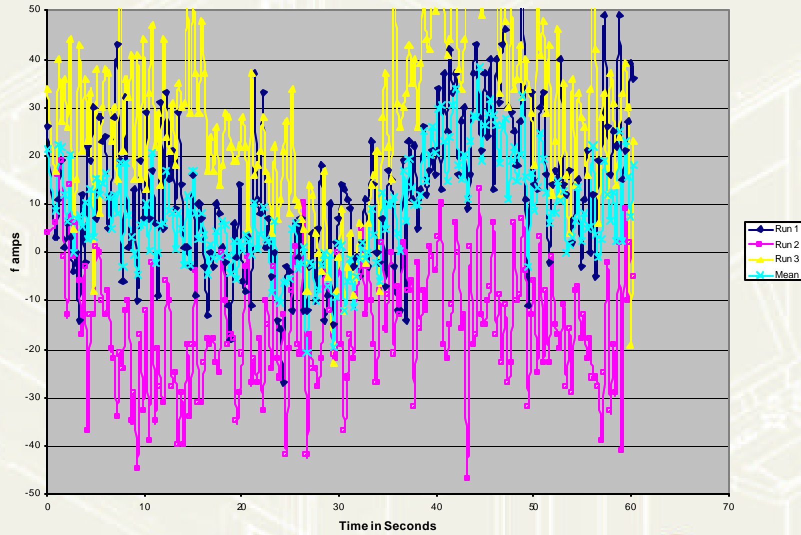
4156B Kelvin Cable ISO box Chuck Connected, with Chiller set to 30 degree



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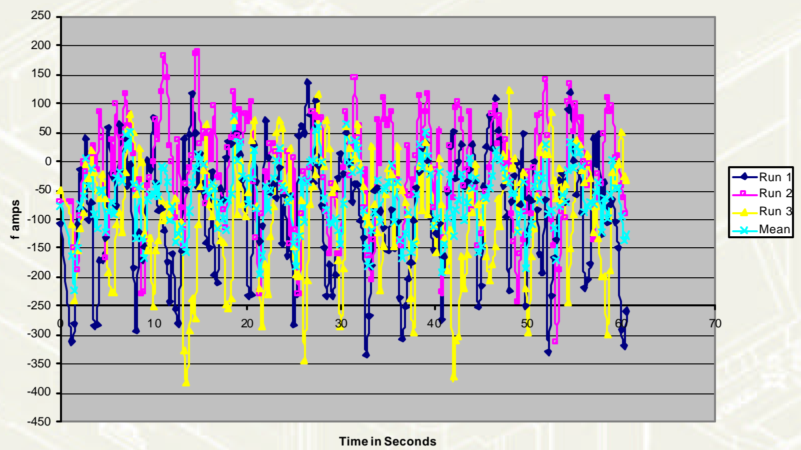
4|200e at 200° C



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Conclusions

> Measured noise levels are seen to be within ±20 fA

> Introduction of a chiller unit brings the noise levels to about ±50fA at 30C

> High temperature probing increases the noise levels to ±250fA

  > Still within the necessary sub threshold range