Effective Bits

A Not-so-New Way to Characterize Data Acquisition System Accuracy

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Original Presentation: April 19, 2005

Accuracy

Is the *First Question* Your Customer Will Ask You

and

Is the *Hardest Parameter* to Characterize and Describe.

Accuracy… What Does It Mean?

A Description of the *Fidelity* With Which a System Can Measure and Reproduce a Real-World Phenomenon.

The Question is: In What Sense?

Instantaneous Time History ... What is the Accuracy of Each Point?
***Worst Case* of a Group (Peak-Peak)**
***RMS Error* of a Group**

Averaged Time History ... What is the Accuracy if We Average Several Points?

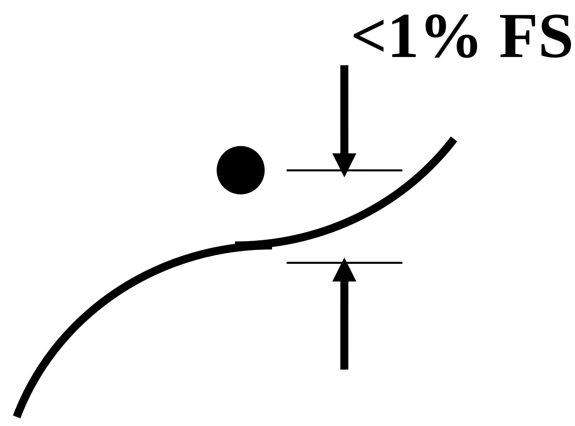
Single Block Spectrum ... If We Calculate the Spectrum, How Accurate Is It?

Ensemble-Averaged Spectrum ... What is the Spectral Accuracy if Averaging is Included?

- ➔ **Different *Laboratories* and Different *Vendors* Use Different Definitions.**
- ➔ **Often, the Proper Definition Depends on the Test to be Performed.**
- ➔ **Often, the Definition is *Not* Described in the Hardware Specification.**

Accuracy .. What Do I Mean?

What Makes Sense is



Individual

Point

Definition

What Do We Want To Do

Characterize the System Under a Simulation of

"Real" Conditions.

- Varying Signal
- "Exercise" Full Range of System
- Look at Every Point

Approach:

Use a Sine Wave to Drive the System

The Concept is Called

Effective Bits

although this is a Misnomer

…Dynamic Range and
Non-Linearity
are what Counts

Effective Bits.. Test Setup/Process

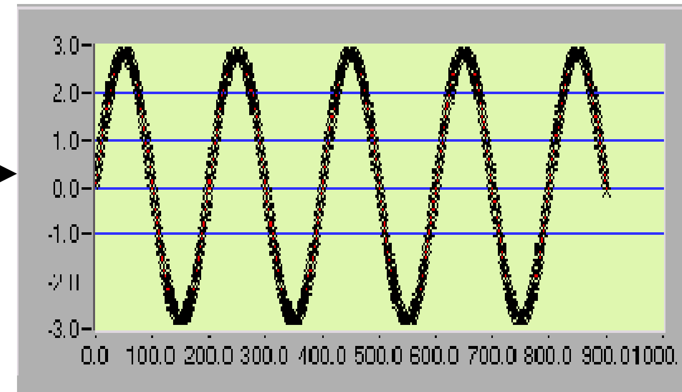
Ultra-Low Distortion Sine Oscillator

F~Sample Rate/100
Amplitude=.95*FSR

Data Acquisition System

Variables:
Sample Rate
Gain

10-100 Cycles

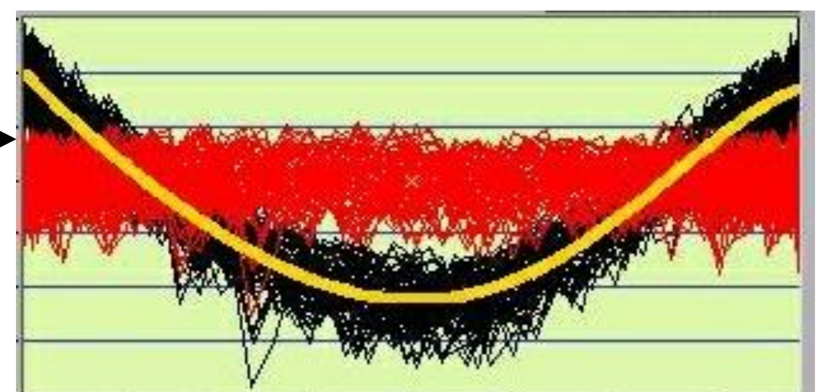


Least-Square Curve Fit
y=a + b*sin(cx +d)

Gain Error (Normalized)
= (True Amp - b)/True Amp

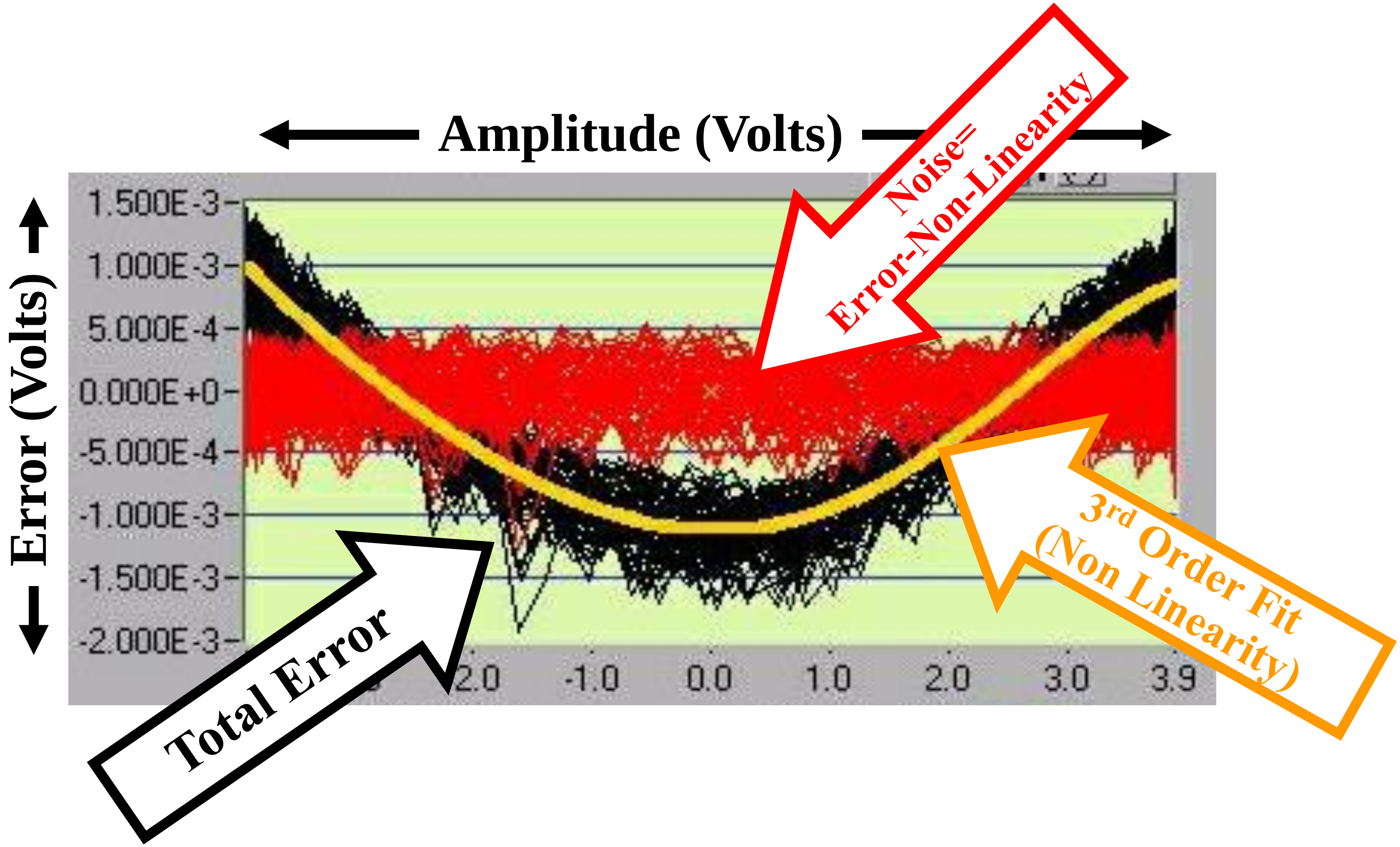
–

“Error”

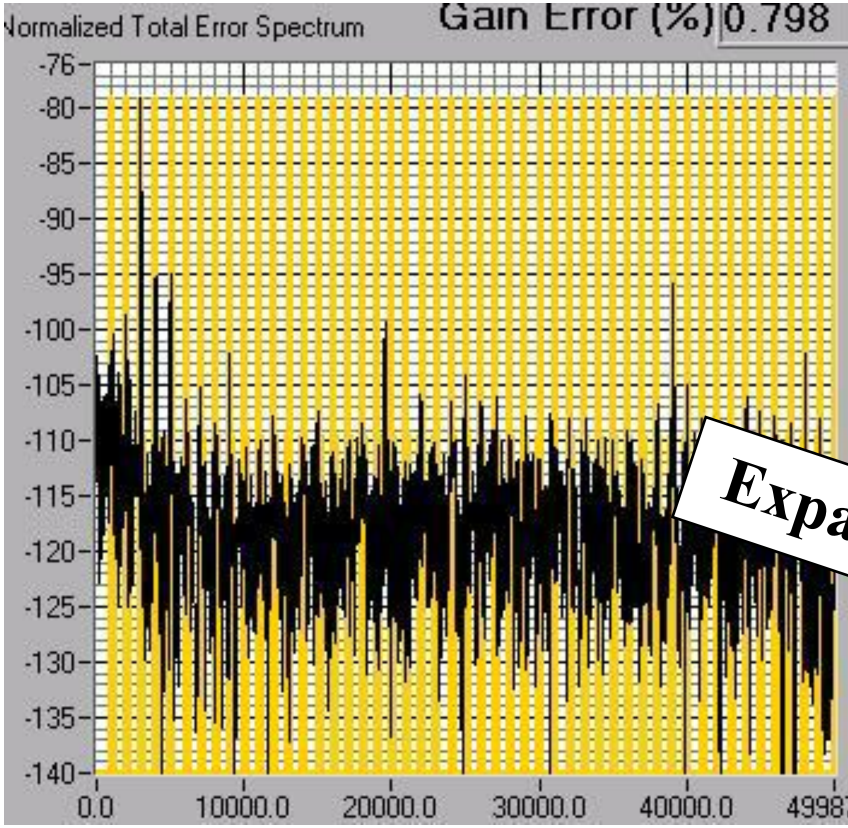


Amplitude

Error Display/Calculation

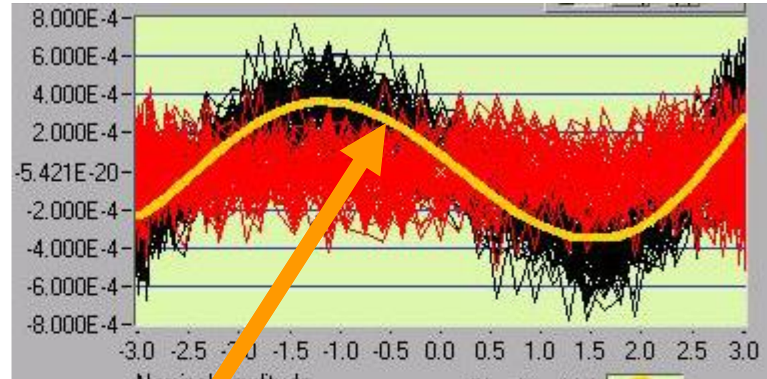


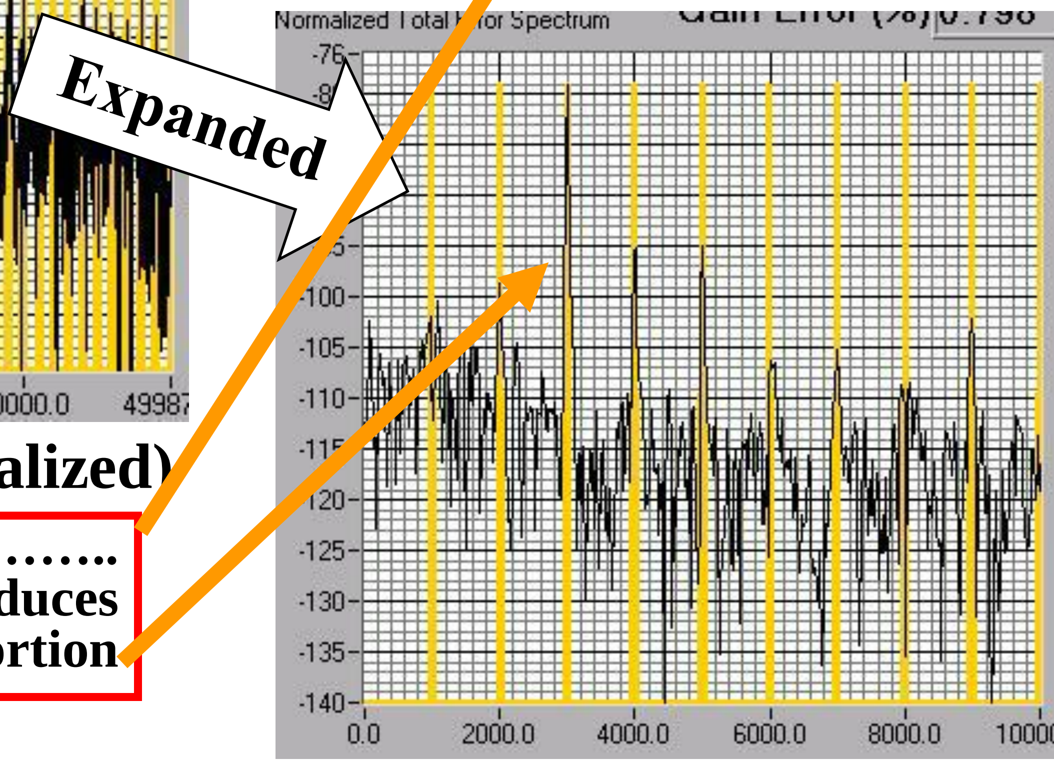
The Spectrum of the Error



Error Spectrum (Normalized)

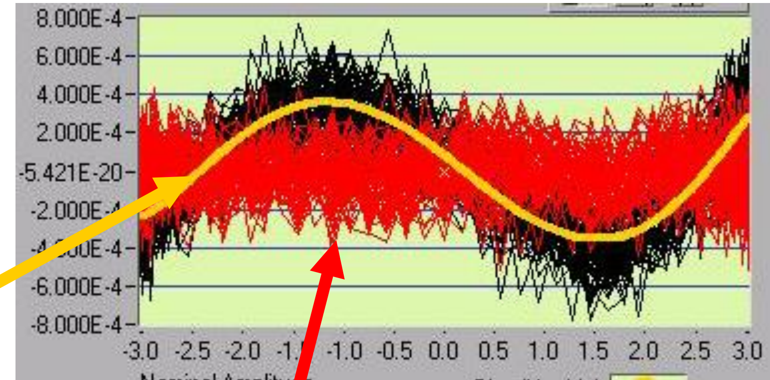
Error





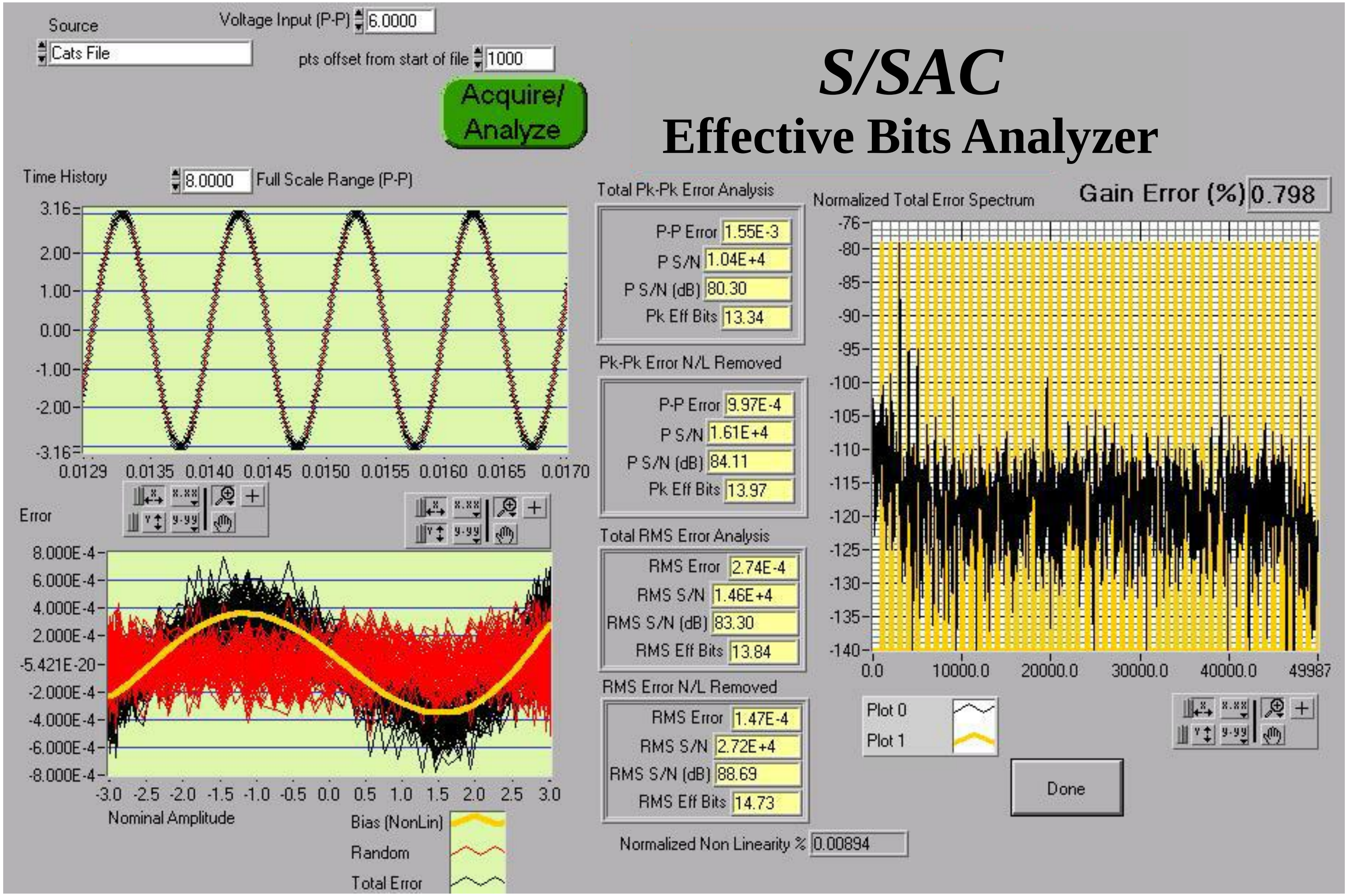
Note:………………….
The Non-Linearity Produces
3rd-Harmonic Distortion

Calculations

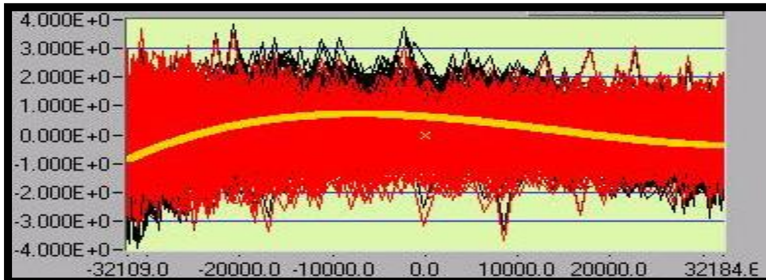


- Do 3rd-Order Least-Square Fit to Error-vs-Amplitude.
  - Characterized Non-Linearity
- Subtract Fit From Error
  - Result is Random Part of the Error
- Find P-P and RMS Values for Total and Random Error.
- Calculate Dynamic Range and Effective Bits
  - → Dynamic Range = Full Scale Range/Error
  - → Effective Bits = $\log_{10}$(Dynamic Range)/$\log_{10}$(2)

The Effective Bits Analyzer



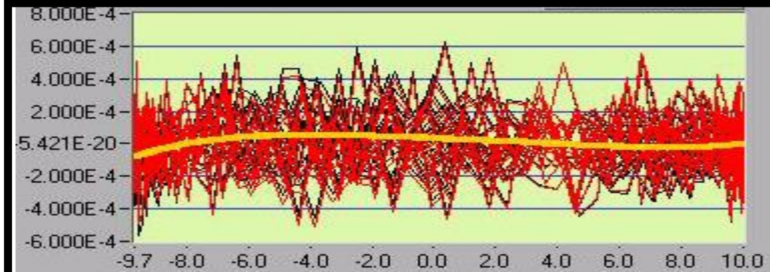
Some Results (16-Bit A/D Converters)



Microstar IDSC (PC) **(data in counts)**

	Dyn Range(dB)	Eff B
RMS	90.4	15.0
P-P	84.5	14.1

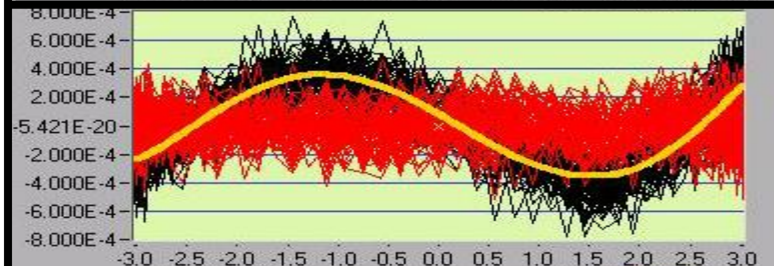
Non Linearity .0024%



NI 4551 DSA (PC) **(with Signal Cond) (data in volts)**

	Dyn Range(dB)	Eff B
RMS	88.2	14.7
P-P	84.4	14.0

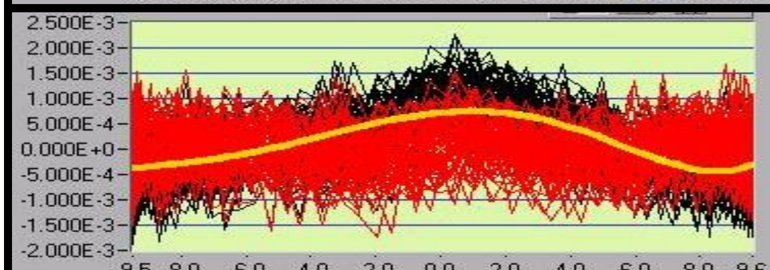
Non Linearity .0013%



Pentek 4275 (VME) **(with Signal Cond) (data in volts)**

	Dyn Range(dB)	Eff B
RMS	83.3	13.84
P-P	80.3	13.34

Non Lin .0089%



VXI A/D **(data in volts)**

	Dyn Range(dB)	Eff B
RMS	77.9	12.95
P-P	73.6	12.2

Non Lin .0119%

Bottom Line(s)

- All Data Acquisition Systems are **_Not Created Equal_**
- ***We Have Tested a Few Systems***

… We Want to Do More