



Fundamentals of Data and Acquisition

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Data is THE most important aspect of any test

- If you have “quality” data, you have a good test.
- If the test fails prematurely, or something goes wrong during the test, as long as the data was recorded, you have a test.

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My definition of quality data

- It was recorded (and saved to disk)
- The data is “accurate” relative to your test
- The instrument location is known
- The instrument direction (polarity) is known
- The instrument survives the test run
- No one touches the instrument between tests

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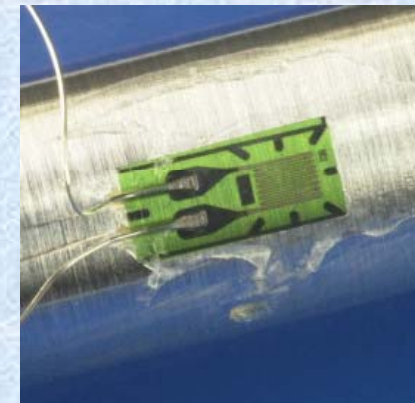


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Typical Instruments

- Displacement: string-pots, linear lvdt or potentiometric
- Force: load cells or acceleration x mass
- Strain: strain gages
- Acceleration: capacitive or piezoelectric
- Vision systems



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TEDS (What are they?)

- A Plug & Play Smart Sensor is a Sensor that is compliant to the IEEE 1451.4 Standard.
- TEDS, or Transducer Electronic Data Sheet, is a set of electronic data in a standardized format defined within the IEEE 1451.4 standard.
- This data specifies what type of sensor is present, describes its interface, and gives technical information such as sensitivity, bridge type, excitation, etc.

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TEDS



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Why TEDS?

- TEDS will save time by reducing setup time.
- Sensor swapping is very easy
- Sensors are truly Plug & Play
- Calibration information stored on TEDS chip
- Calibrations can be polynomial, look-up tables, FRF or custom
- IEEE defined standard; instrument can be transferred to NEES sites and used immediately

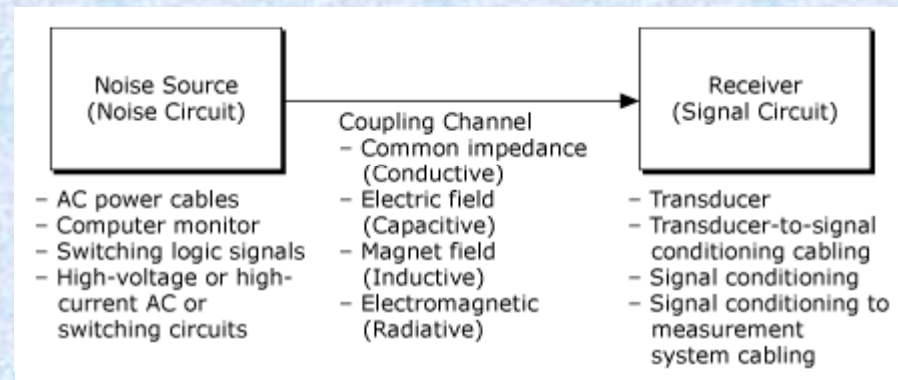


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Importance of the Cable

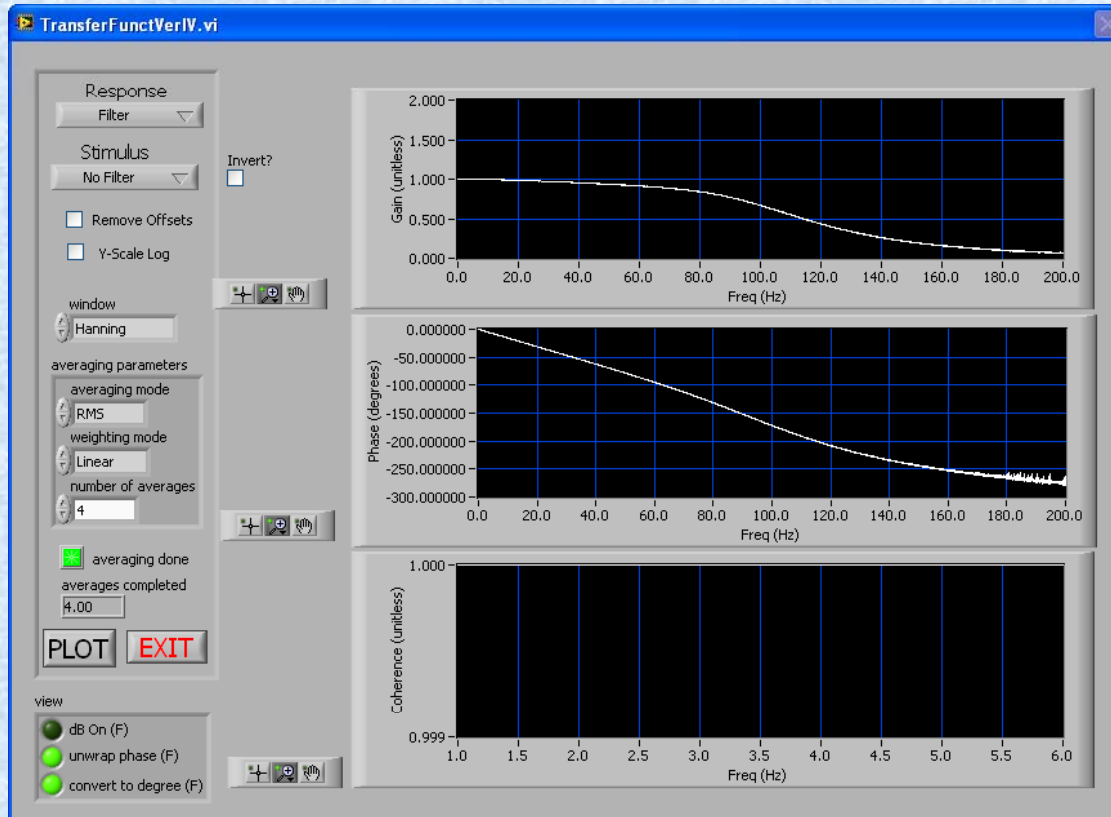
- Has a resistance (and impedance)
- There will be a voltage drop
- Should be twisted pair (coupling)
- Temperature effects?
- Length generally not a problem if using remote sense
- Wireless?



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Filters and Sampling Rates



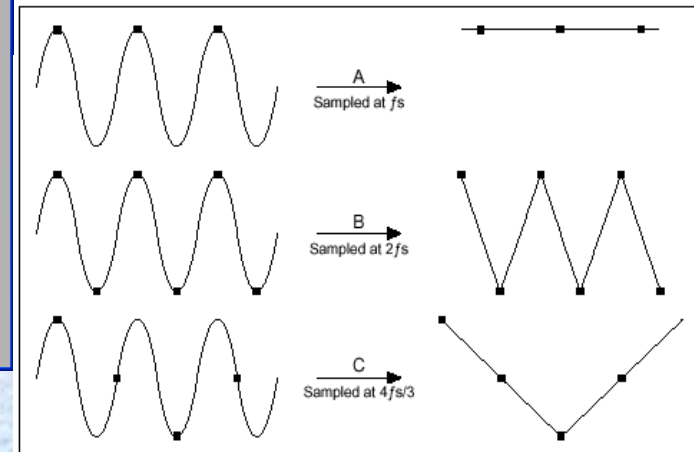
Sample Rate = 256 Hz

Nyquist = 128 Hz

Rule of Thumb (10) ~ 25 Hz

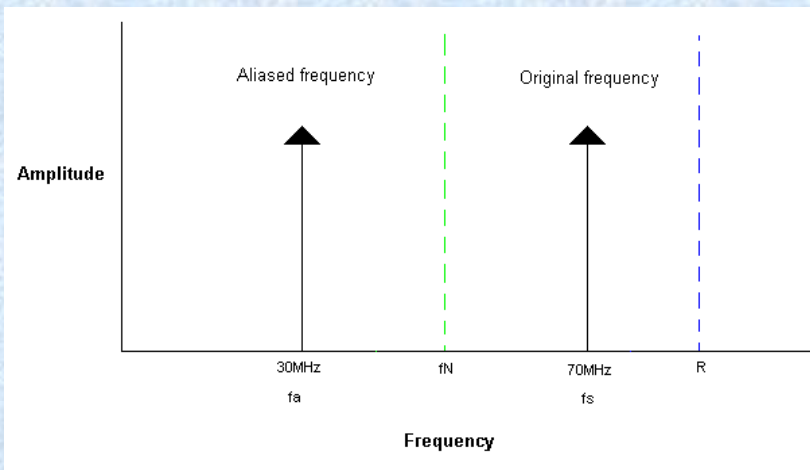
Filter = 100 Hz

At 25 Hz ~ 98 % of signal amplitude

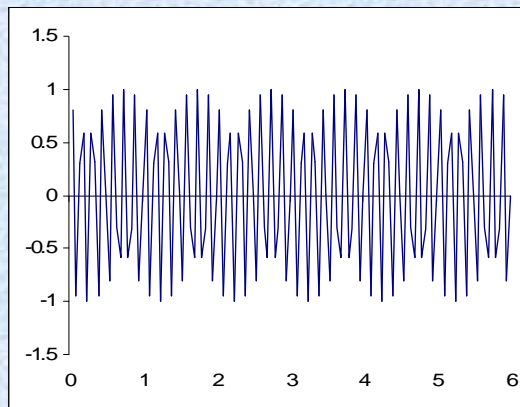


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Aliasing

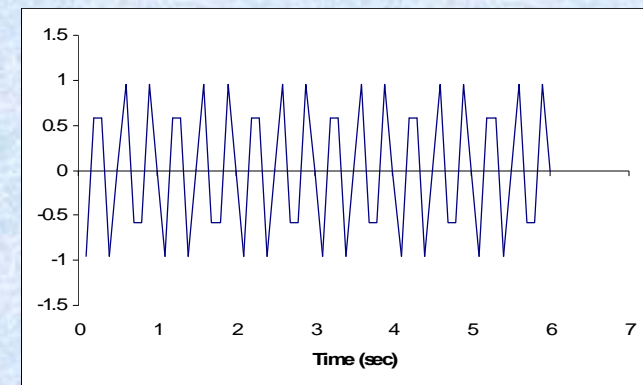


Aliasing can occur if you have no pre-A/D filters or incorrect sampling rate



Input Signal

- Sample rate = 10 Hz
- Nyquist = 5 Hz
- No filters
- Injected signal = 7 Hz
- BUT data shows a 3 Hz signal!!!!

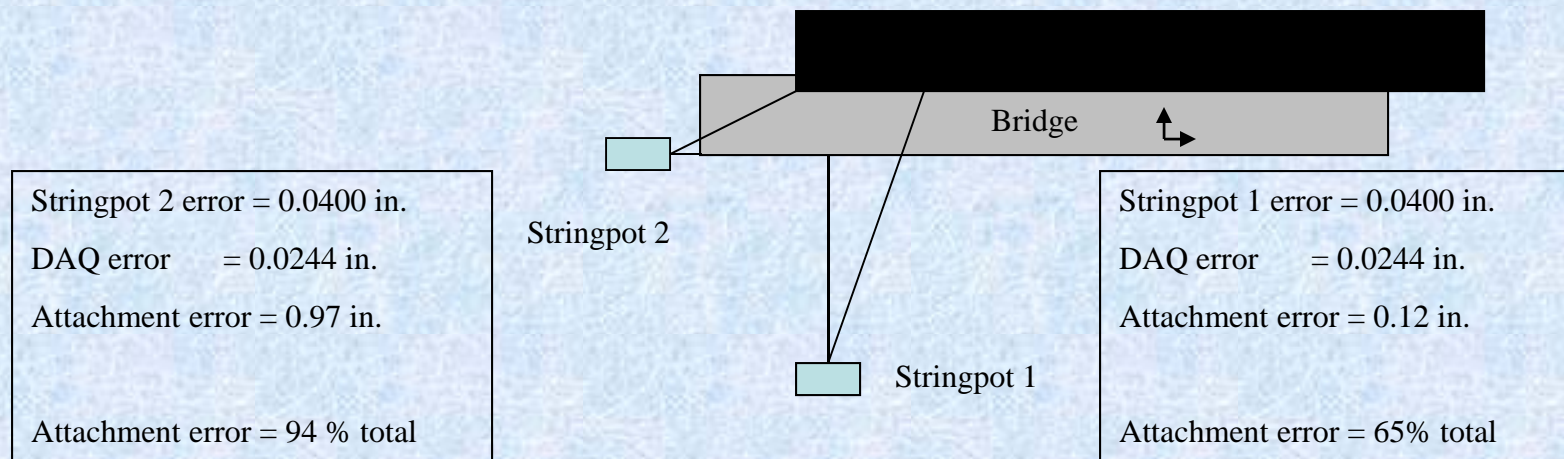


Measured Signal

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Sensitivity of the Instrument Location

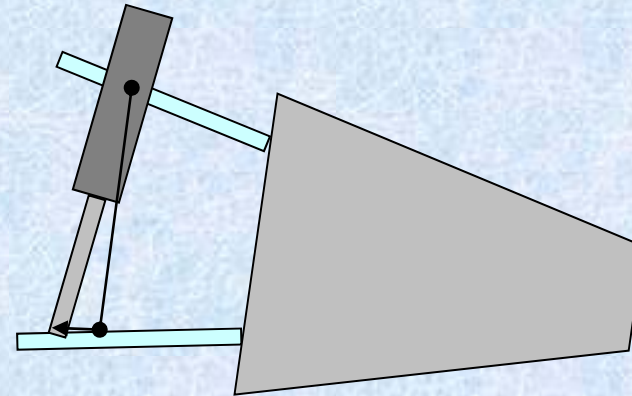
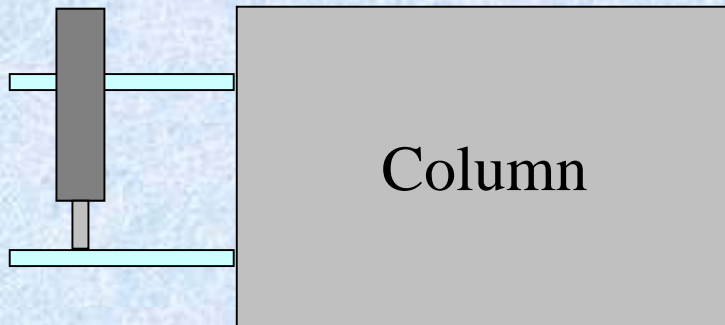
- Instrument Attachment = 90%(?) of total error
- Instrument Calibration = 5%(?) of total error
- DAQ calibration = 5%(?) of total error



Must do sensitivity analysis or else resolve the kinematics

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Mechanical Attachment



Error due to attachment

At 0.02 rad/inch curvature:

Novotechnik = 0.80128 in

Actual = 0.80000 in

Error = 0.16%

Error due to “bumping the instrument between tests”

At 0.02 rad/inch curvature:

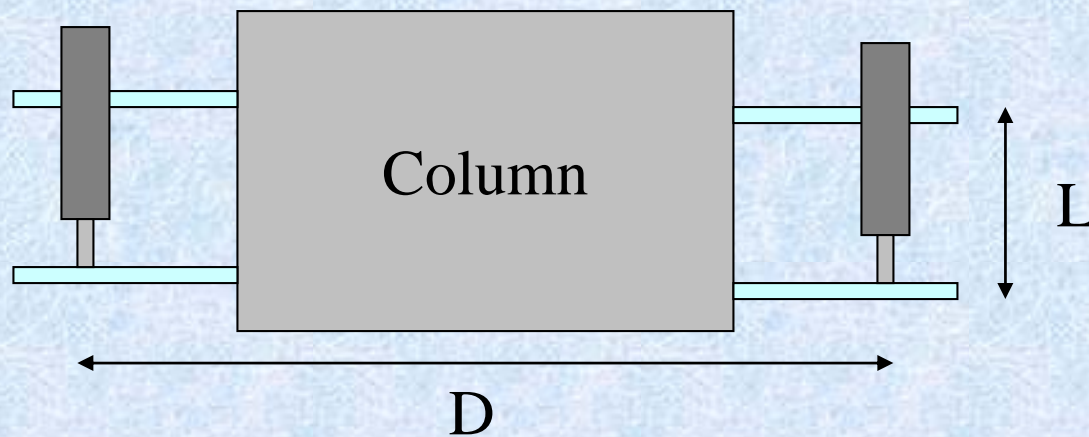
Bump = 0.85000 in

Actual = 0.80000 in

Error = 6.25%

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Post processing data using location measurements



Error due to your measurement D

Novotechniks = 0.8 in

For D = 16.00 Curvature = 0.0250 rad/in

For D = 16.25 Curvature = 0.0246 rad/in

Error = 1.6%

Error due to your measurement L

Novotechniks = 0.8 in

For L = 4.00 Curvature = 0.0250 rad/in

For L = 4.25 Curvature = 0.0235 rad/in

Error = 6.3%

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A few comments

- How much accuracy do you need?
- In general, our instruments are more accurate than our needs.
- It's our "environment" that makes accuracy difficult
- A strain gage's accuracy depends mostly on how well you attach the gage.
- A strain gage on a rebar in a concrete column tested to failure is a difficult environment.
- A 40" stringpot has an accuracy of about ± 0.02 inches.
- A 2" novotechnik has an accuracy of about ± 0.001 inches.
- Measuring specimen base shear is difficult

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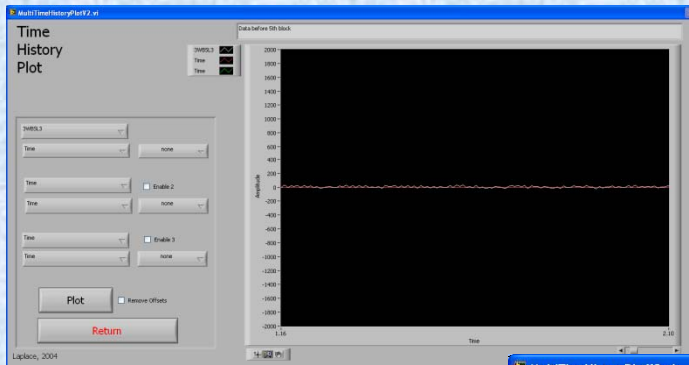
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Strain gage (DAQ) resolution



Minimum strain gage resolution?

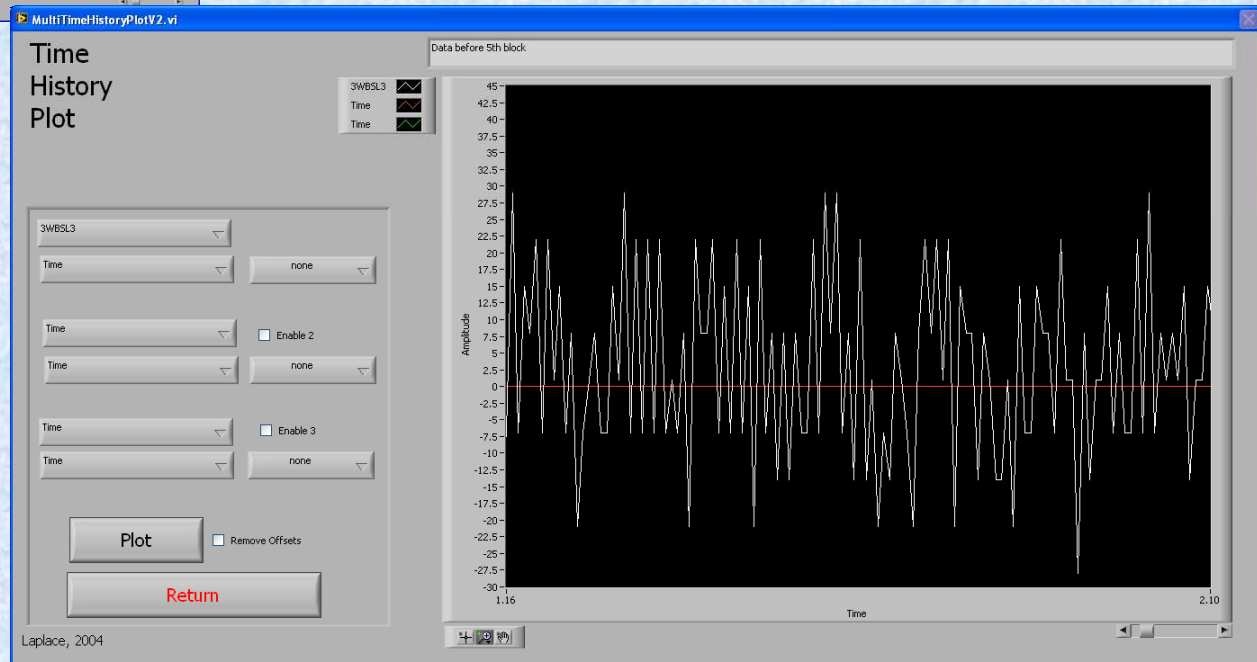
$$\sim (20 \text{ volts}) / (50 \text{ gain}) / (2^{16} \text{ bit}) * (982353 \text{ sensitivity}) =$$

$$6 \text{ uS} = .000006 \text{ in/in}$$

Maximum gage measurement? (TML says 10-20% strain)

$$\sim (10 \text{ volts}) / (50 \text{ gain}) * (982353 \text{ sensitivity}) =$$

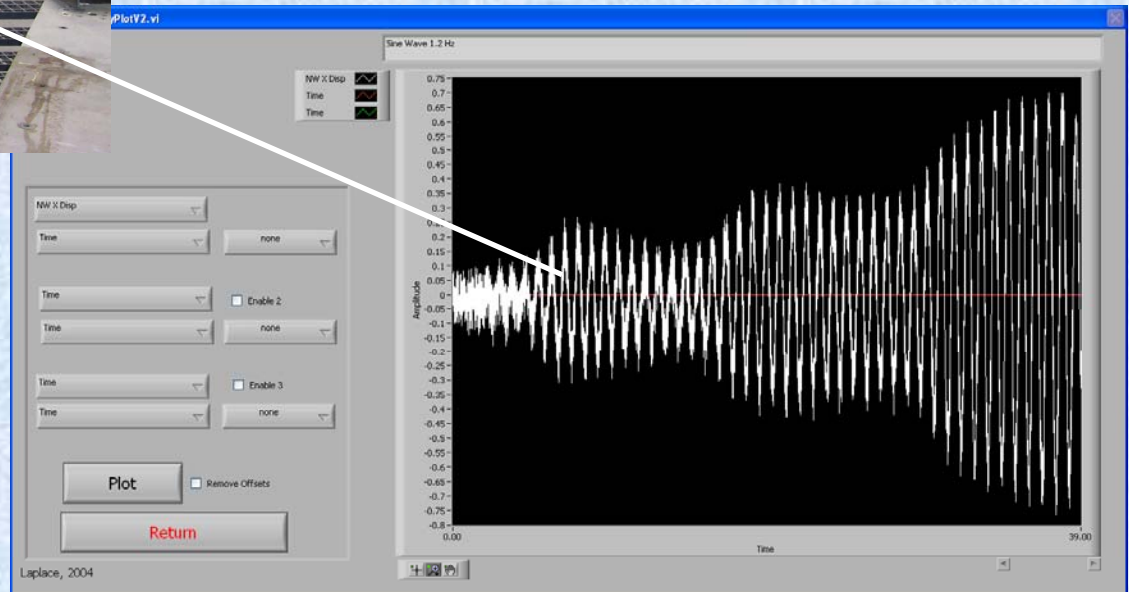
$$196471 \text{ uS} = .196471 \text{ in/in}$$



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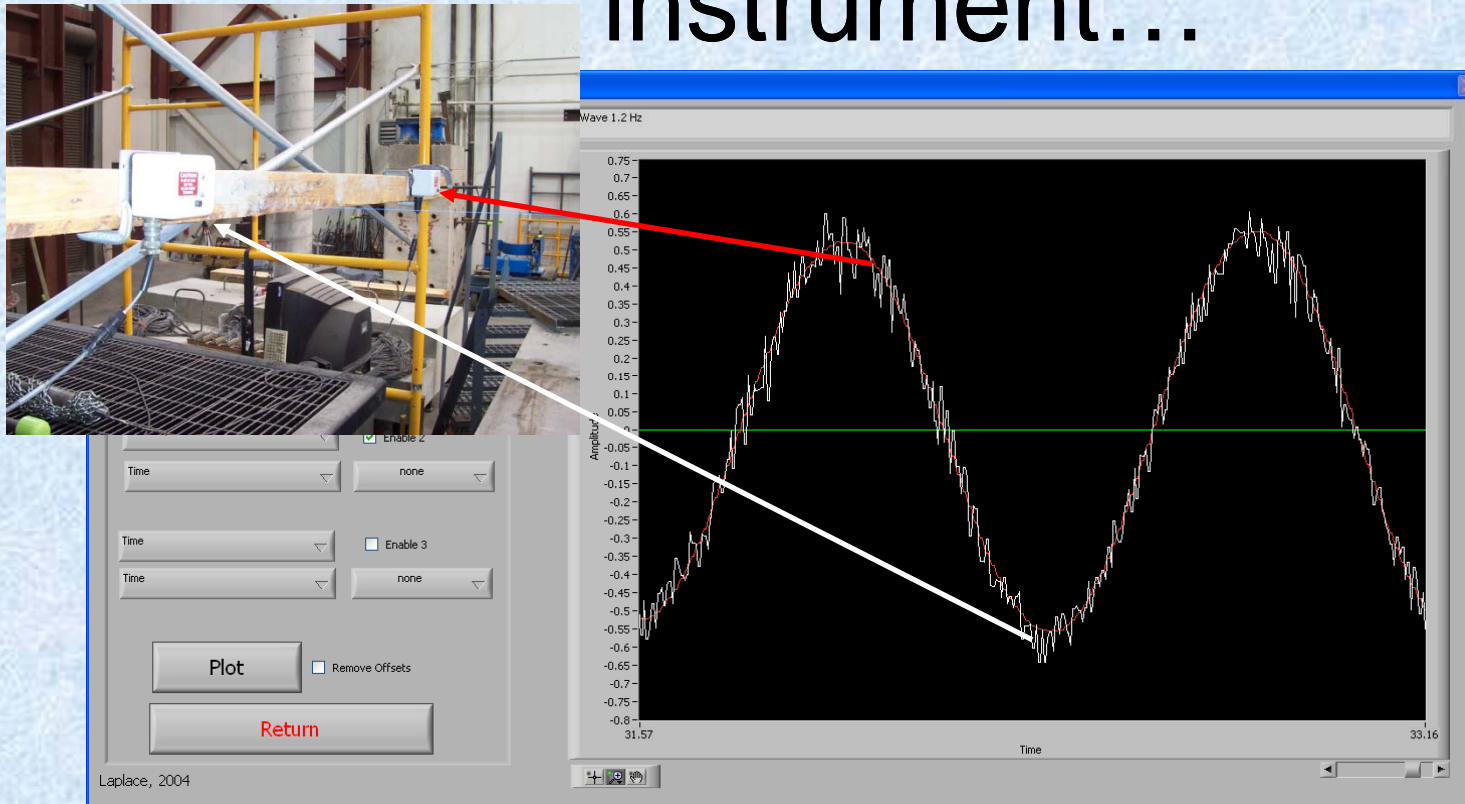
What is wrong with this instrument?



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Compare it to a redundant instrument...

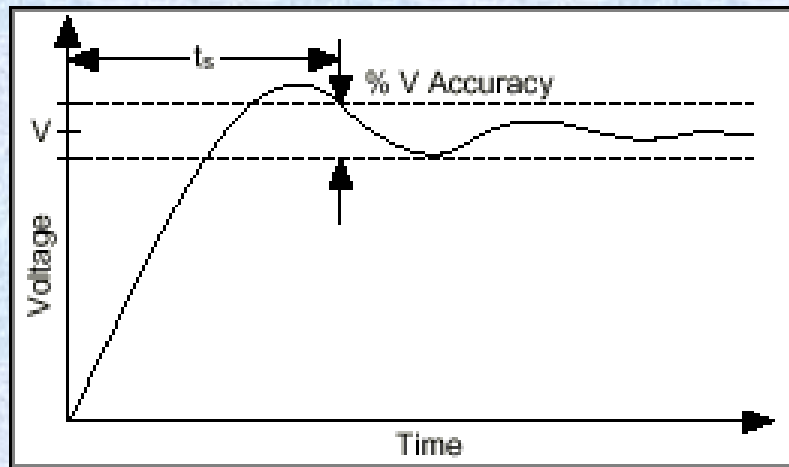


Begin Diagnosis: Check calibrations, swap instruments, swap channels, swap cables, ground loops, noise interference...

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It's the A/D amplifier settling time due to the previous channel.



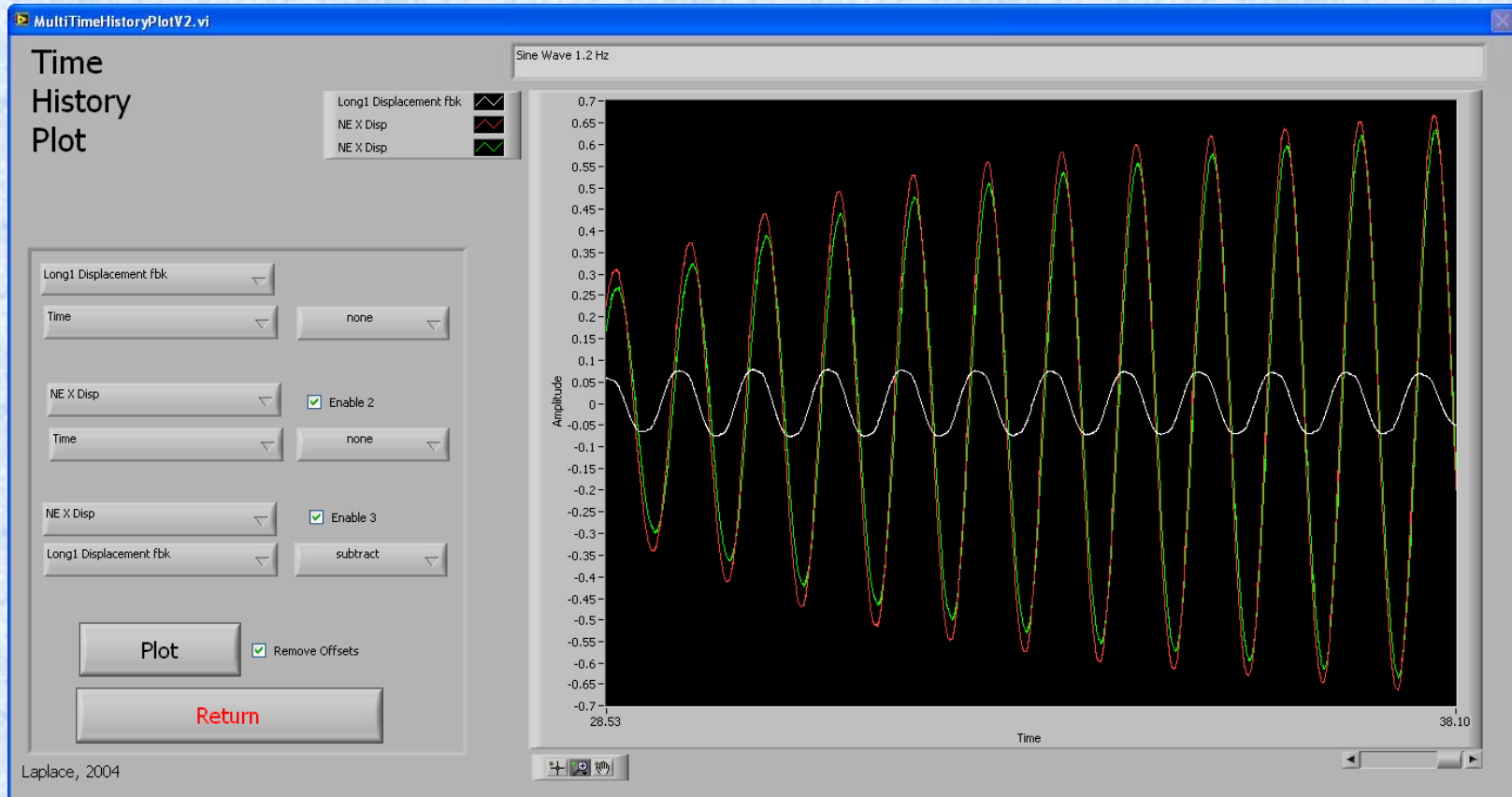
Settling time can be affected by:

1. Gain
2. Multiplexing
3. Source impedance
4. Transmission line resistance and capacitance

What was the previous channel? A load cell with a gain of 1000.

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Absolute versus relative



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Conclusions

- You can spend a lifetime in data and acquisition and still not be an expert
- Our equipment and instruments are very good
- Our methods of attachment and reference frames can be improved
- Always plot the data (data in tables can be confusing)
- You can't have too much meta-data

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