WORCESTER POLYTECHNIC INSTITUTE

MECHANICAL ENGINEERING DEPARTMENT

Engineering Experimentation
ME-3901, D'2012

Lecture 01: Introduction

12 March 2012

General information

Instructors: Cosme Furlong
Office: HL-151
Tel.: (508) 831-5126
cfurlong@wpi.edu

Christopher Scarpino
Office: HL-153
Tel.: (508) 831-4927
cscarpino@wpi.edu

http://www.wpi.edu/~cfurlong/me3901.html

Teaching Assistants: Ivo Dobrev (ivo_d@wpi.edu)
Peter White (pawhite@wpi.edu)

Course description

A course designed to develop analytical and experimental skills in modern engineering measurement methods based on electronic instrumentation and computer-based data acquisition systems. The lectures are concerned with the engineering analysis and design as well as the principles of instrumentation, whereas the laboratory periods afford the student an opportunity to use modern devices in actual experiments. In these Sections of ME-3901, state-of-the-art microelectromechanical (MEMS) sensors and actuators will be introduced.

Lecture topics include:
review of engineering fundamentals and, among others, discussions of standards, measurement and sensing devices, experiment planning, data acquisition, analysis of experimental data, and report writing. Laboratory experiments address both mechanical and thermal systems and instrumentation in traditional mechanical engineering: heat transfer, flow measurement/visualization, force/torque/strain measurement, motion/vibration measurement.

Recommended background: Mathematics (MA-2051), Thermo-fluids (ES-3001, ES-3003, ES-3004), Mechanics (ES-2501, ES-2502, ES-2503), Materials (ES-2001).

General information

Office hours: please complete General Information Form (GIF)

Instructors: Cosme Furlong / Chris Scarpino
Everyday from 3:00 to 3:50 or by appointment
To be rescheduled after reviewing your completed GIF

Teaching Assistants:
To be scheduled after reviewing your completed GIF

Grading

The grade for the course will be based on:

20% FOR HOMEWORK,

20% FOR EXAMS,

50% FOR LABORATORY REPORTS, and

10 % FOR LABORATORY AND LECTURE PARTICIPATION AND ATTENDANCE.

Homework

HOMEWORK IS ASSIGNED WEEKLY. Homework will be collected on Mondays **the week after it is assigned**. Except April 16th, when homework will be collected on Tuesday.

All homework assignments are done by each individual without collaboration.

Exams

THERE WILL BE TWO (2) EXAMS: MIDTERM and FINAL.
Exams will be closed books and closed notes, unless otherwise indicated.

All exams are done by each individual without collaboration, unless otherwise indicated.

Laboratories

THERE WILL BE FIVE (5) LABORATORY EXPERIMENTS. Each experiment requires laboratory efforts and the write-up of a report.

All laboratory preparations are done individually and jointly within small laboratory groups (2 students per group.)

Data analysis, reduction, and synthesis are done individually and jointly within small laboratory groups.

Each laboratory group completes the laboratory reports jointly.

Laboratory reports are due **Wednesday**, the week after they are finished. **There is NO credit for later reports.**

General information

Review syllabus: see corresponding handout

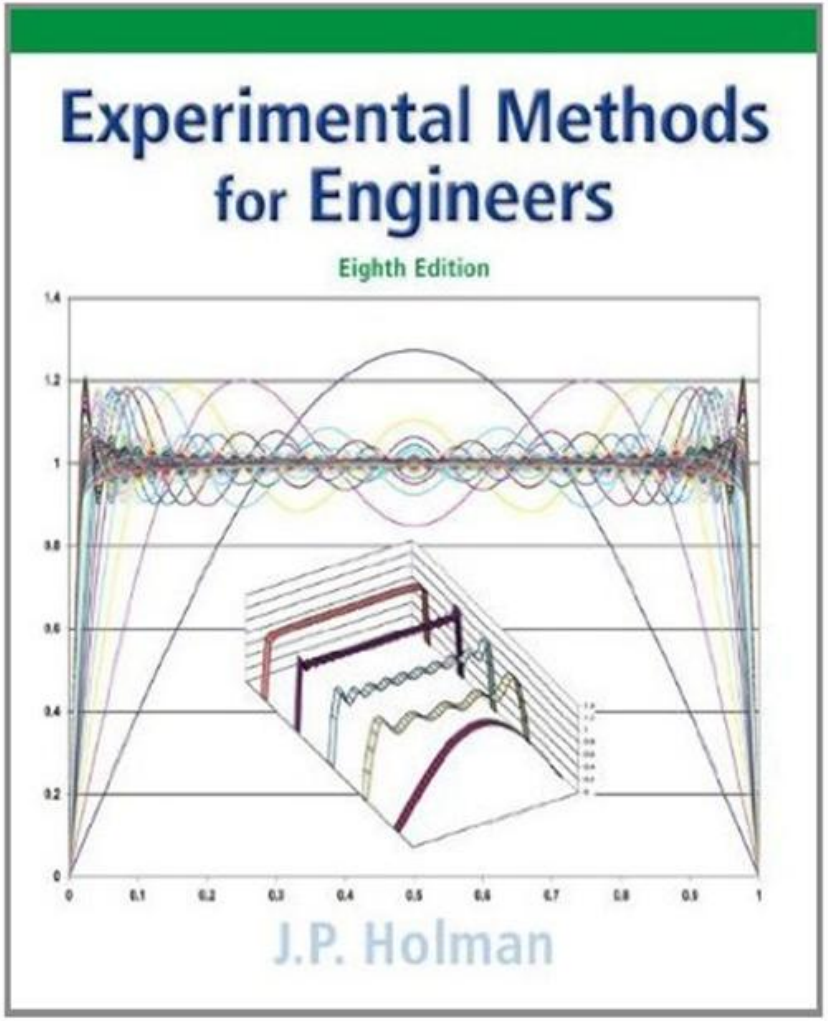
General information

Review general guidelines for preparation of laboratory reports: see corresponding handout (HER)

General information: laboratory safety

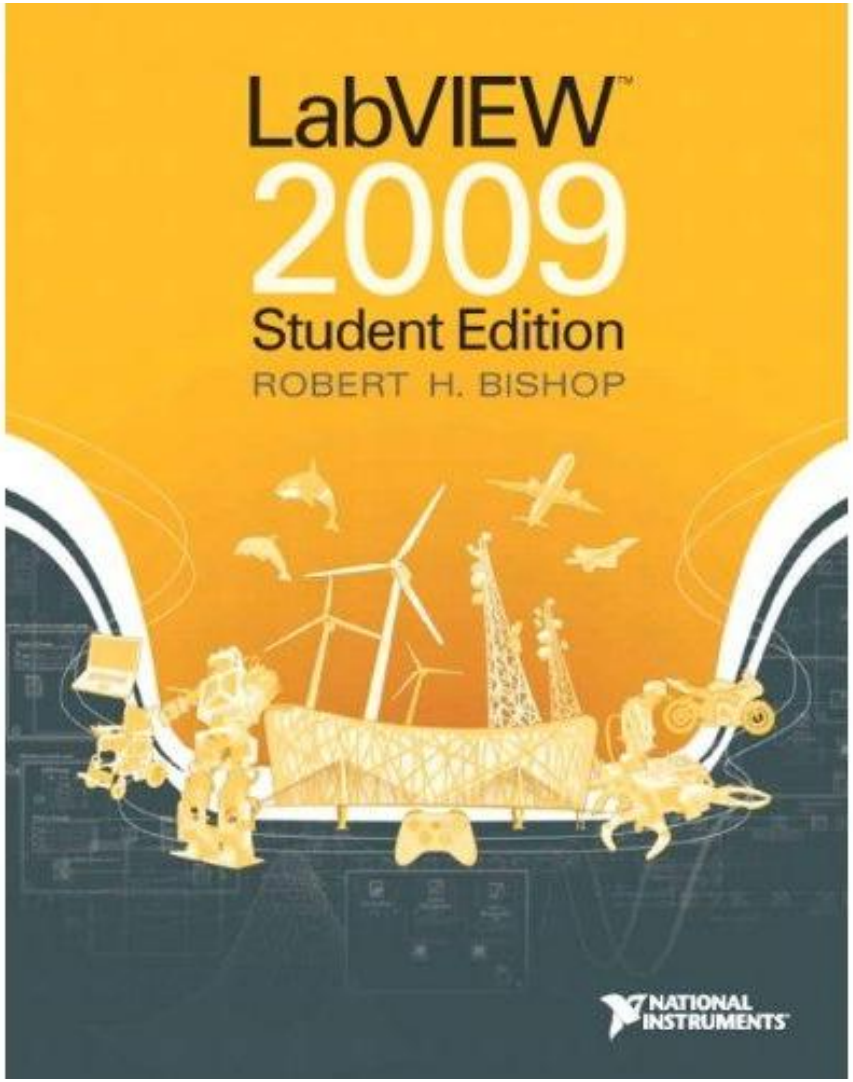
Review note on safety: please complete handout

Required text: Holman, 8th Edition



Hardcover: 800 pages
Publisher: McGraw-Hill Science/Engineering/Math; 8 edition
Language: English
ISBN-10: 0073529303
ISBN-13: 978-0073529301
Product Dimensions: 9.2 x 7.4 x 1.3 inches

Recommended text: Bishop



Original version comes with a CD (with software/examples)

Paperback: 752 pages

Publisher: Prentice Hall; 1 Pap/Dvdr edition (December 28, 2009)

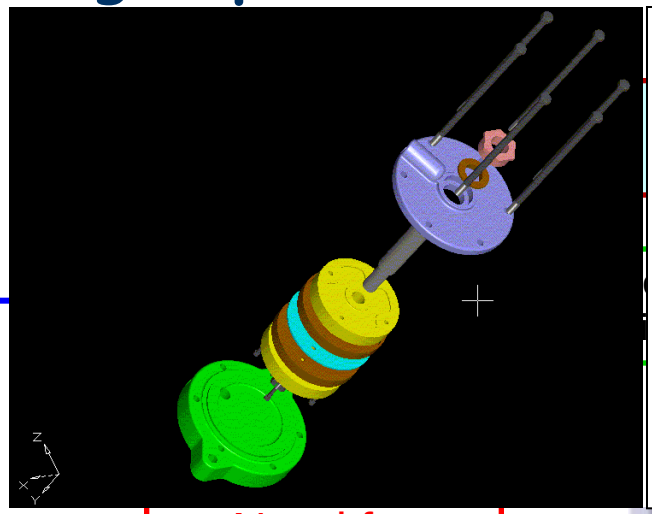
Language: English

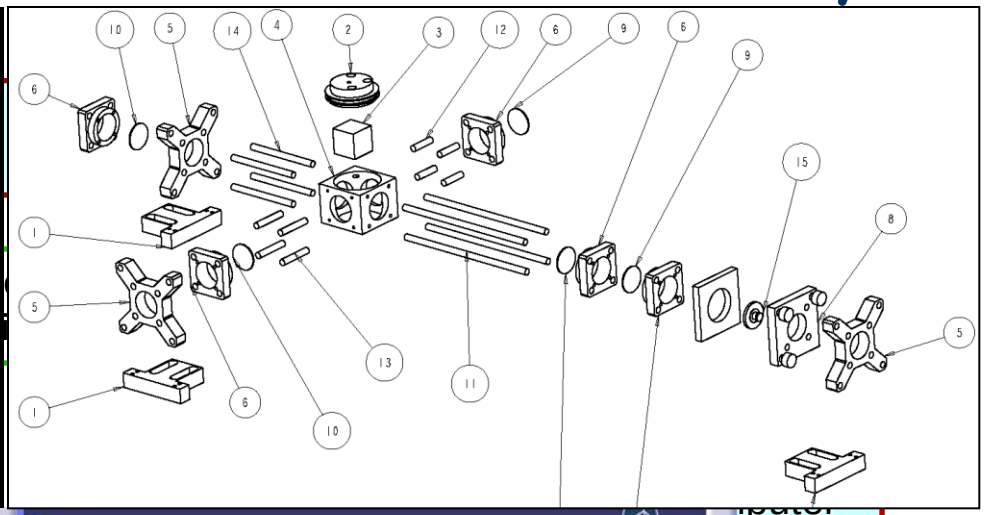
ISBN-10: 0132141299

ISBN-13: 978-0132141291

Product Dimensions: 9 x 7.3 x 1.2 inches

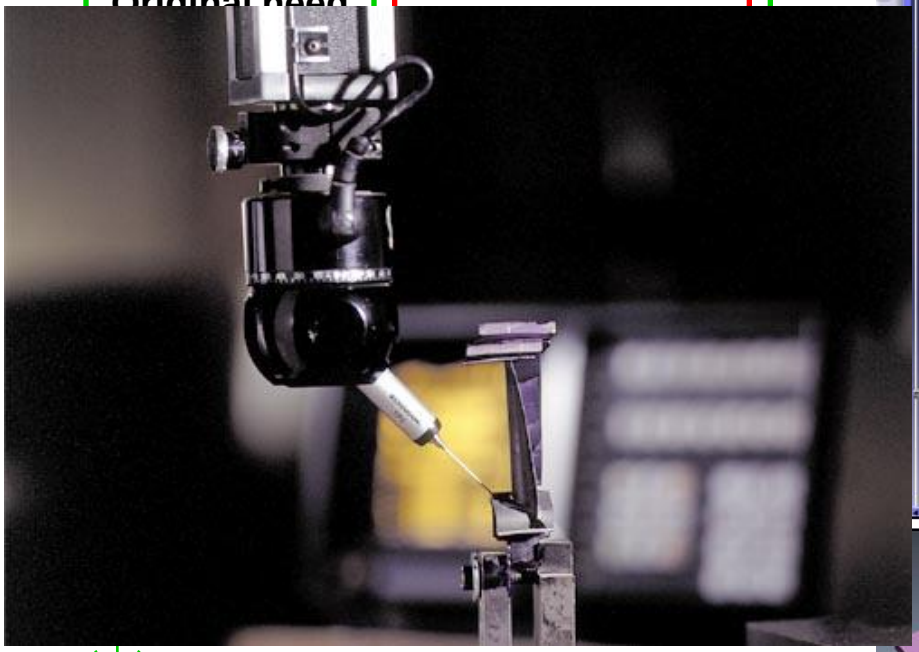
Engineering experimentation and the CAD/CAE/CAM cycle

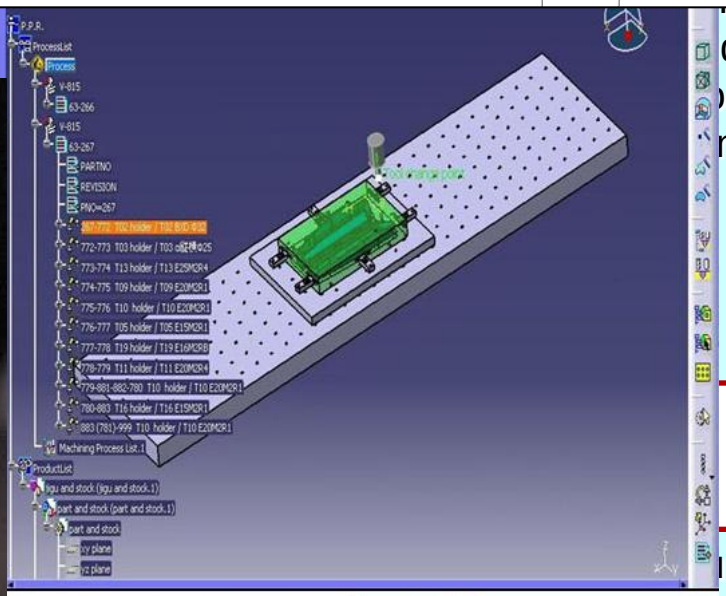


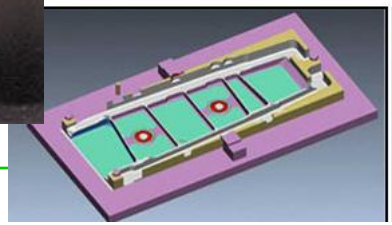


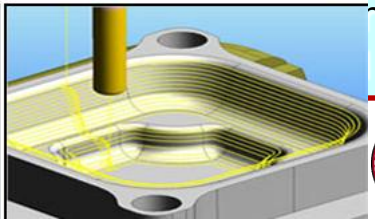
Need for

Or



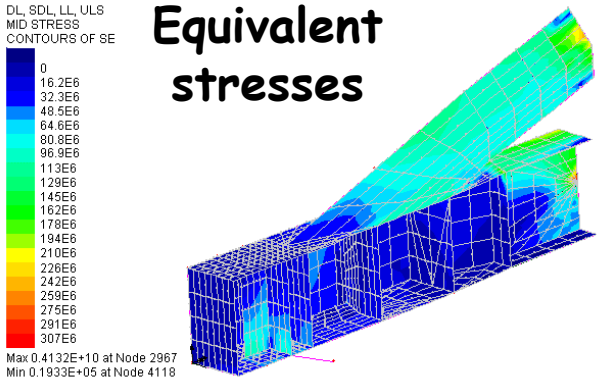






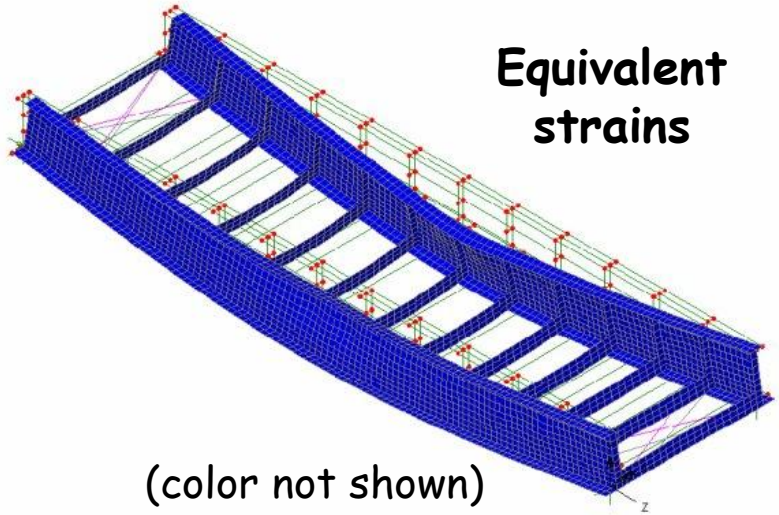
Experimental stress analysis in the field: examples

Bridges: calculated/measured (estimated) **stresses**



Equivalent stresses

Bridges: calculated/measured (estimated) **strains**



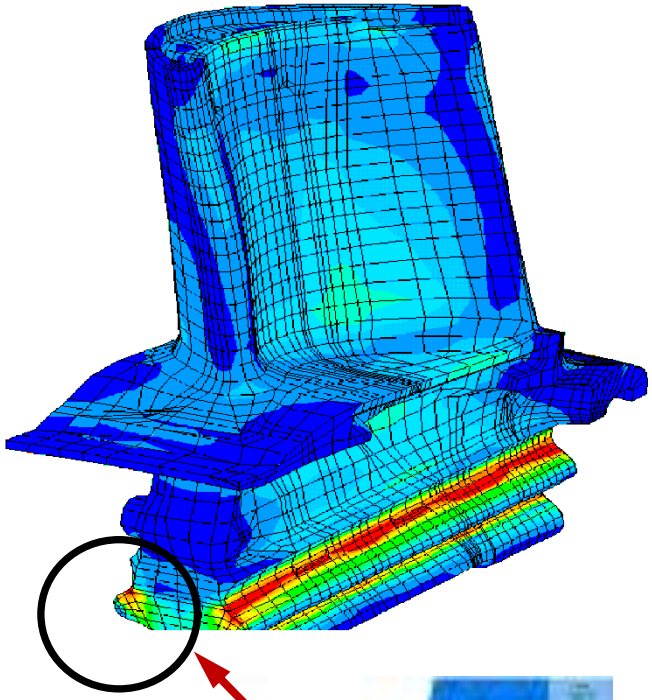
Equivalent strains

(color not shown)

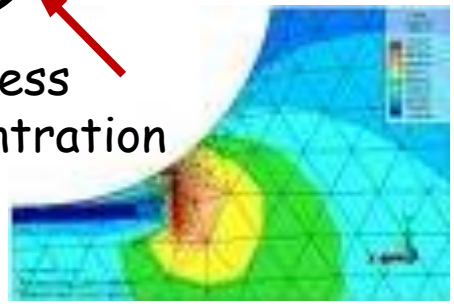
Experimental stress analysis in the field: examples

Turbine engine: experiments

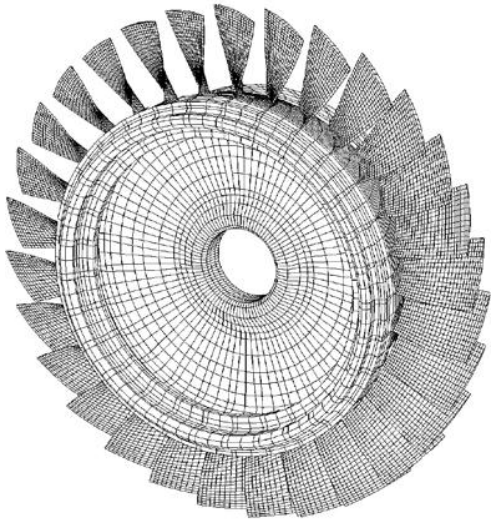
Calculated (estimated) thermo-mechanical induced **stresses** on a blade



Stress concentration



Model of a rotor

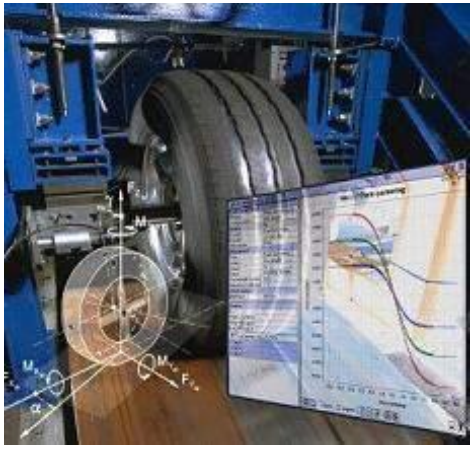


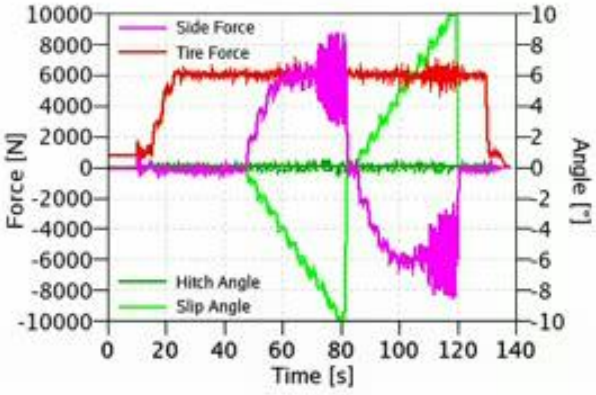
Engineering experimentation in the field: examples

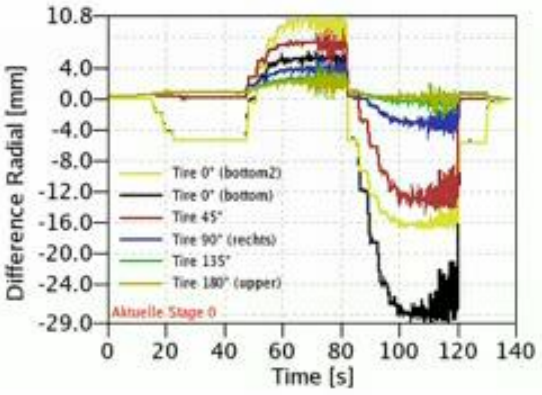
Tire/dynamics testing

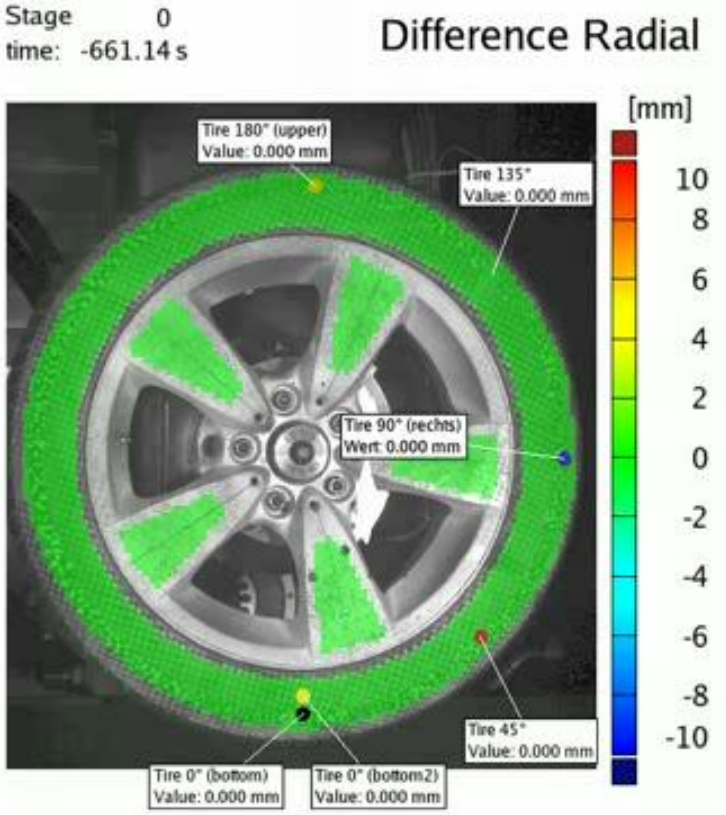
Displacement measurements:
large strains induced,
dynamic loads

Testing machine



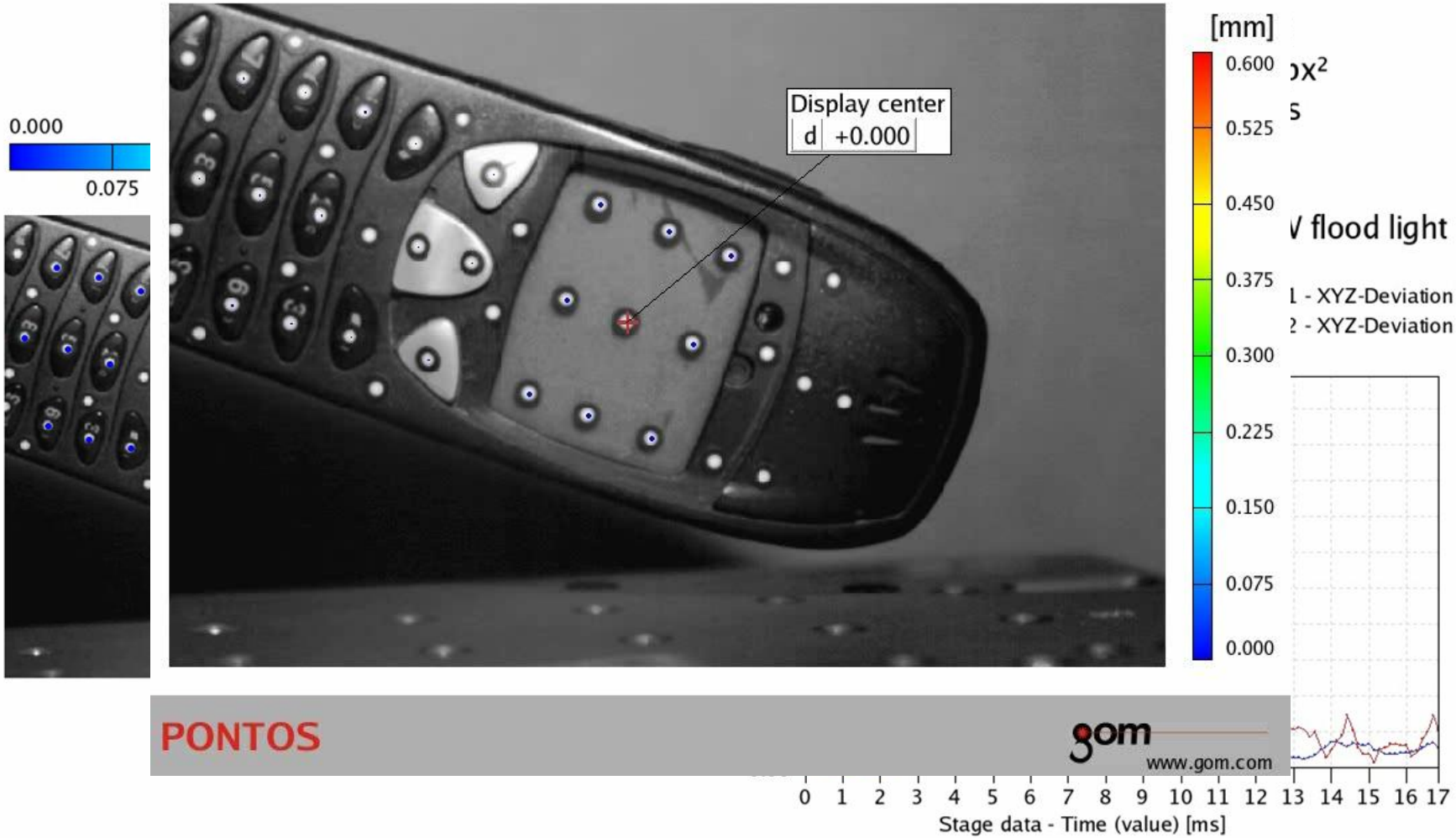






Engineering experimentation in the field: examples

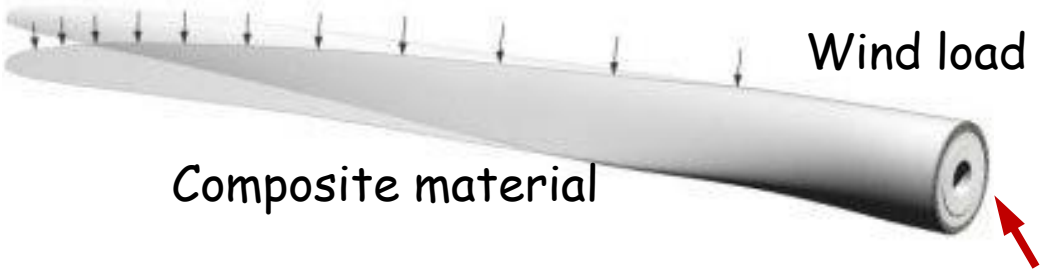
Impact loads/stresses/strains

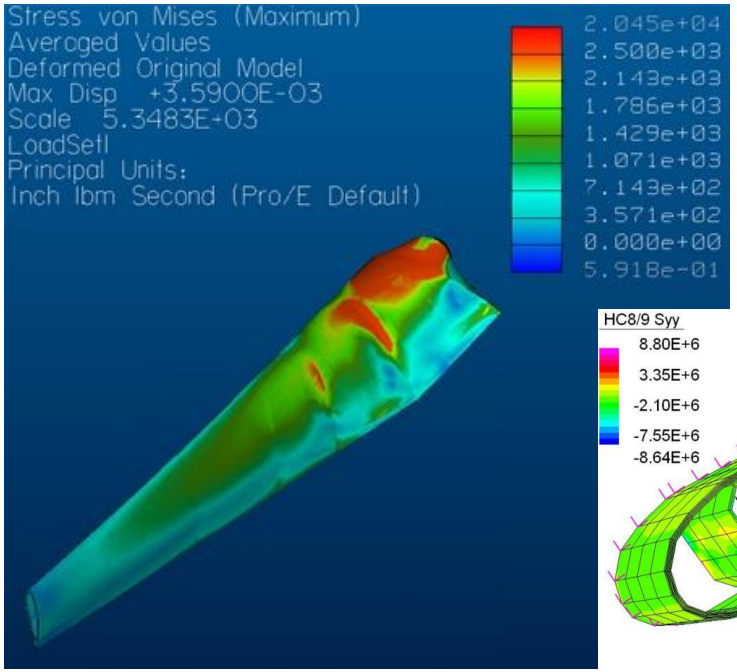


Engineering experimentation in the field: examples

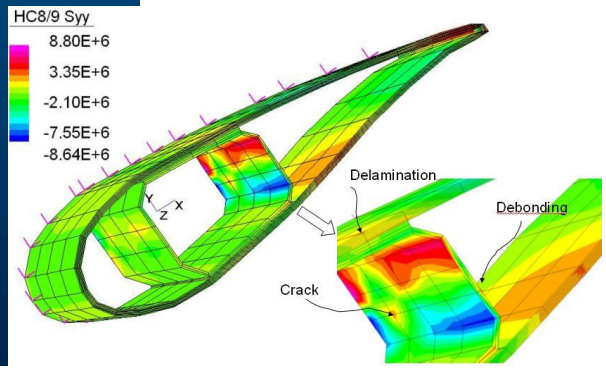
- Turbine blade: Vestas' 850 kW at Holy Name high school, Worcester MA

Analyzed as a cantilever beam





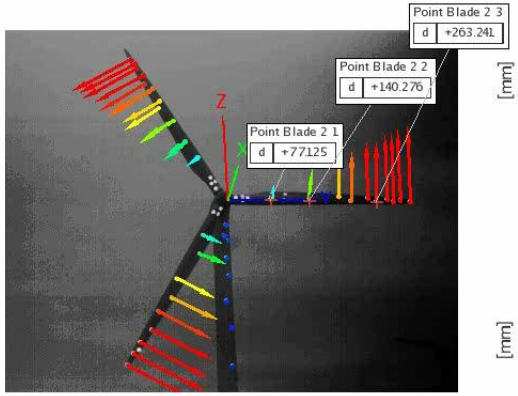
Computed equivalent stresses

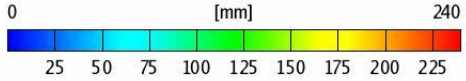


Engineering experimentation in the field: examples

- Turbine blade: Vestas' 850 kW at Holy Name high school, Worcester MA

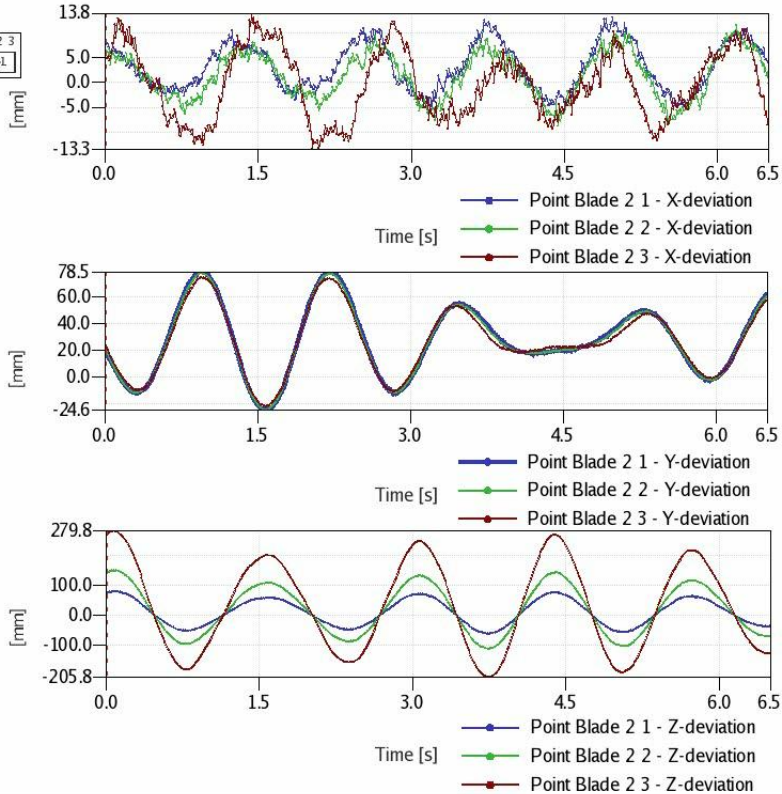
Blades dynamics





Deformation (YZ-Vector)

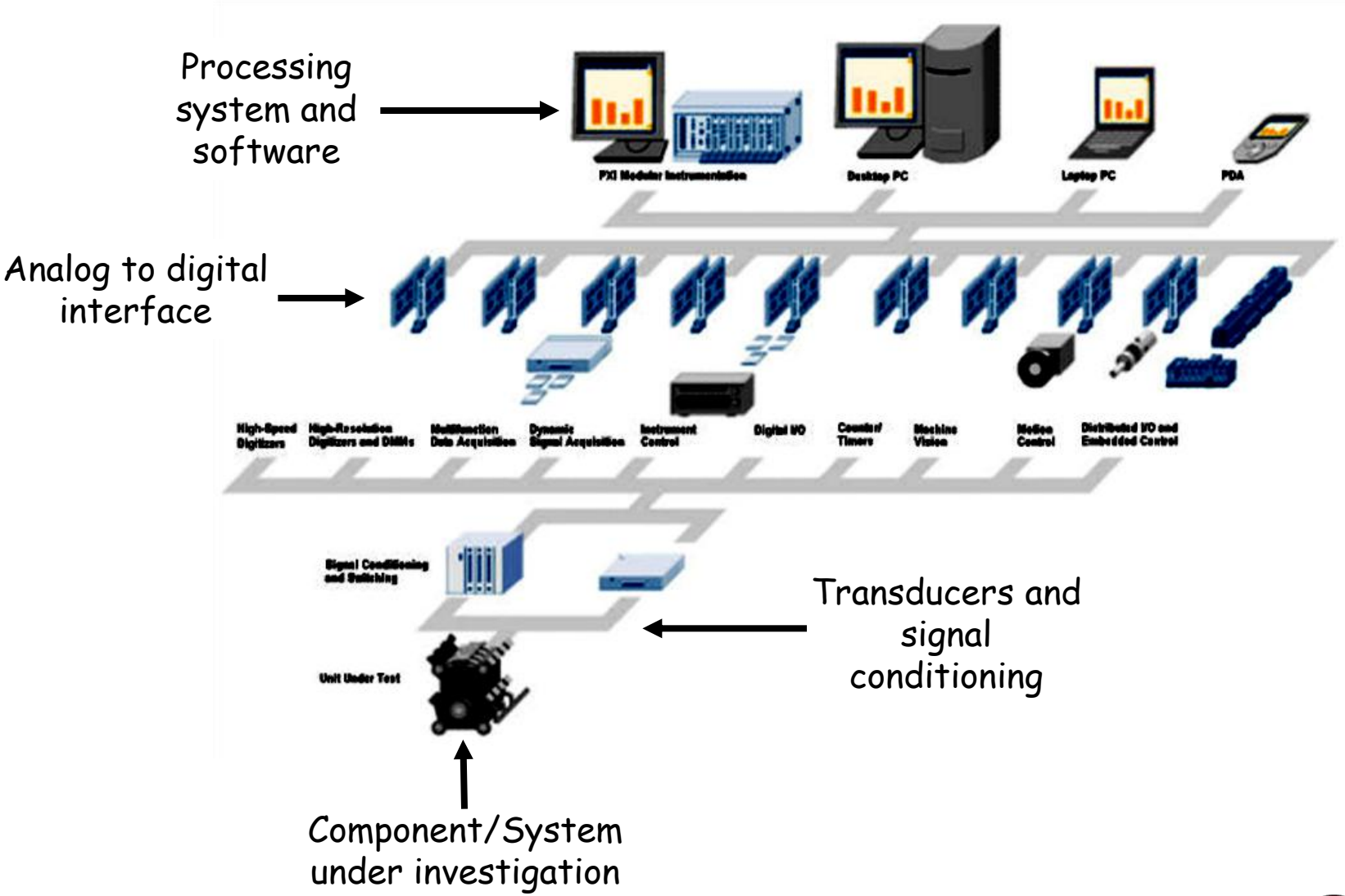
embrake_stop.dyn
Date: 18.12.2007
Stage 1



PONTOS

gom www.gom.com

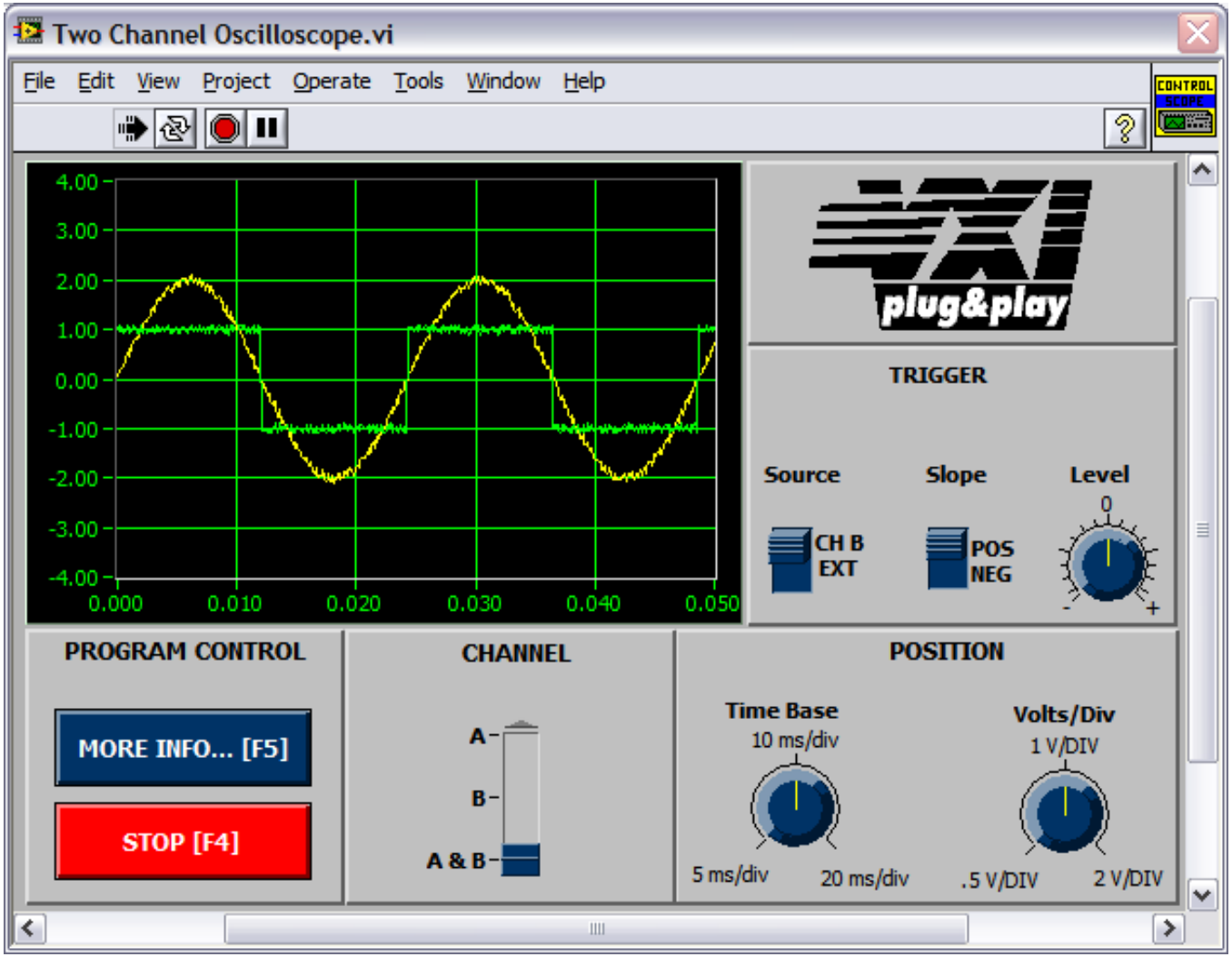
Modern measurement systems



Modern measurement systems: LabView 2009

Virtual instrument (VI)

Digital oscilloscope

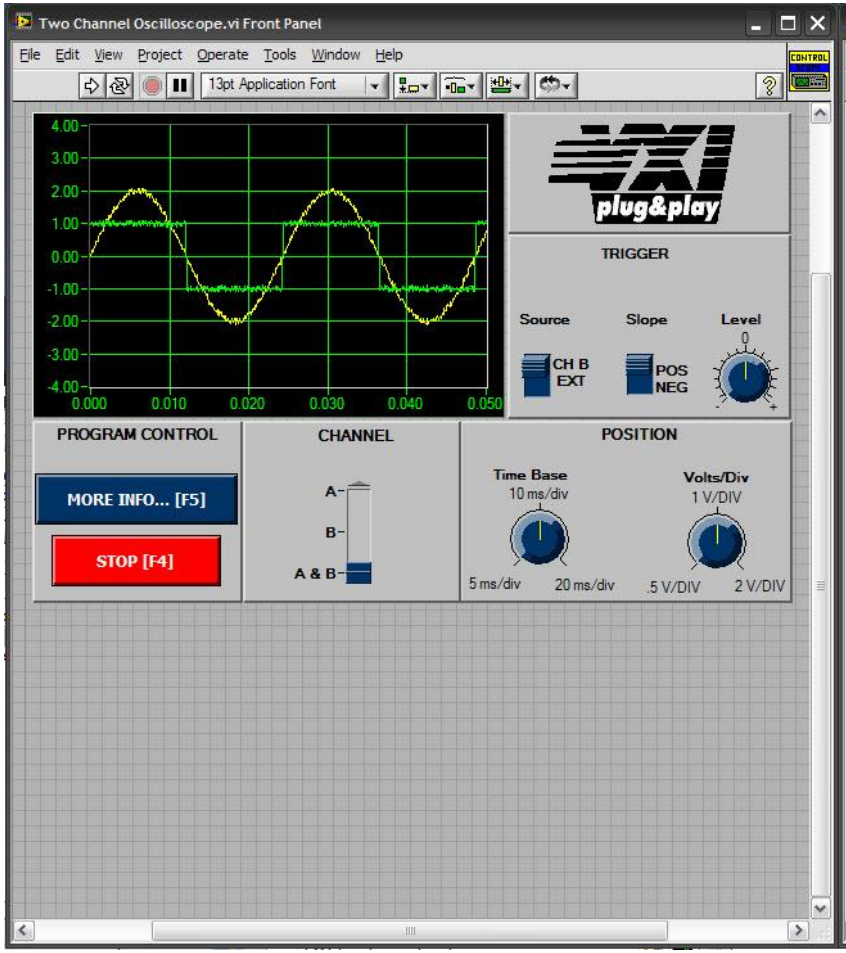


Modern measurement systems: LabView 2009

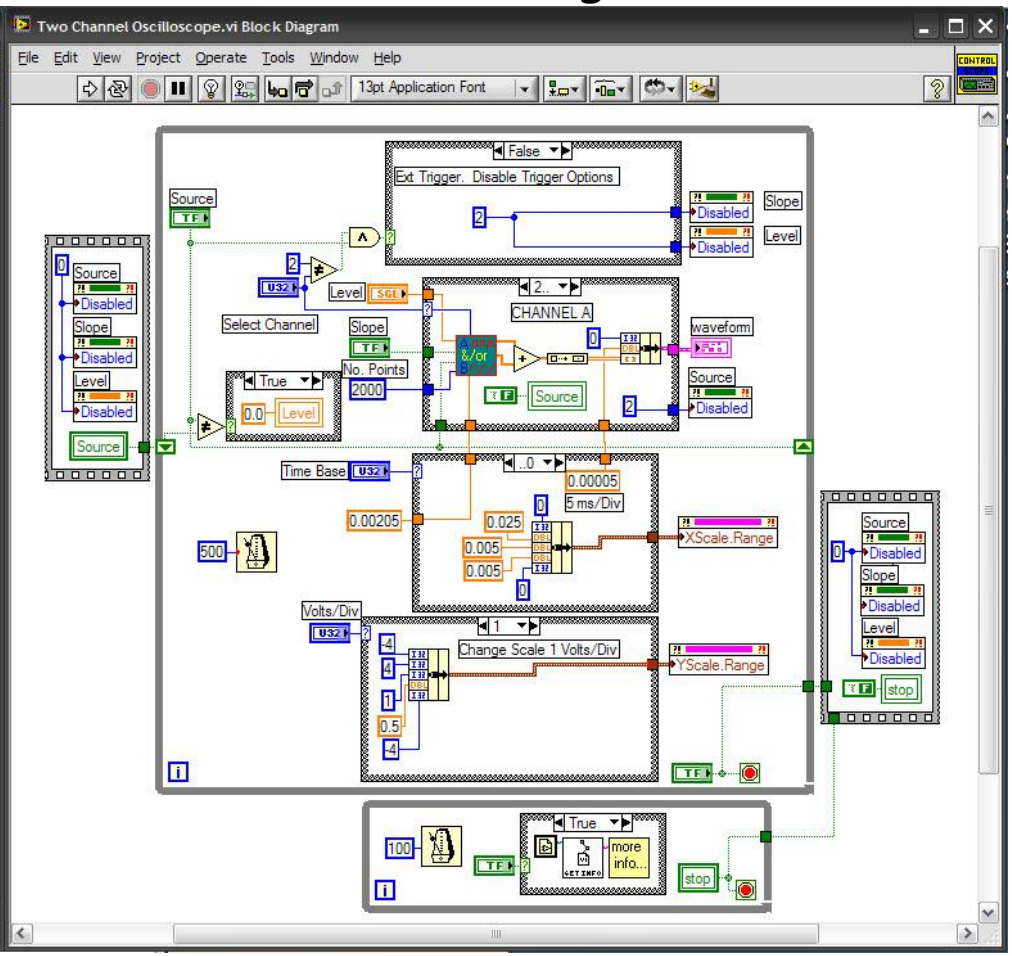
Virtual instrument (VI)

Behind Digital Oscilloscope VI

Front Panel



Block Diagram

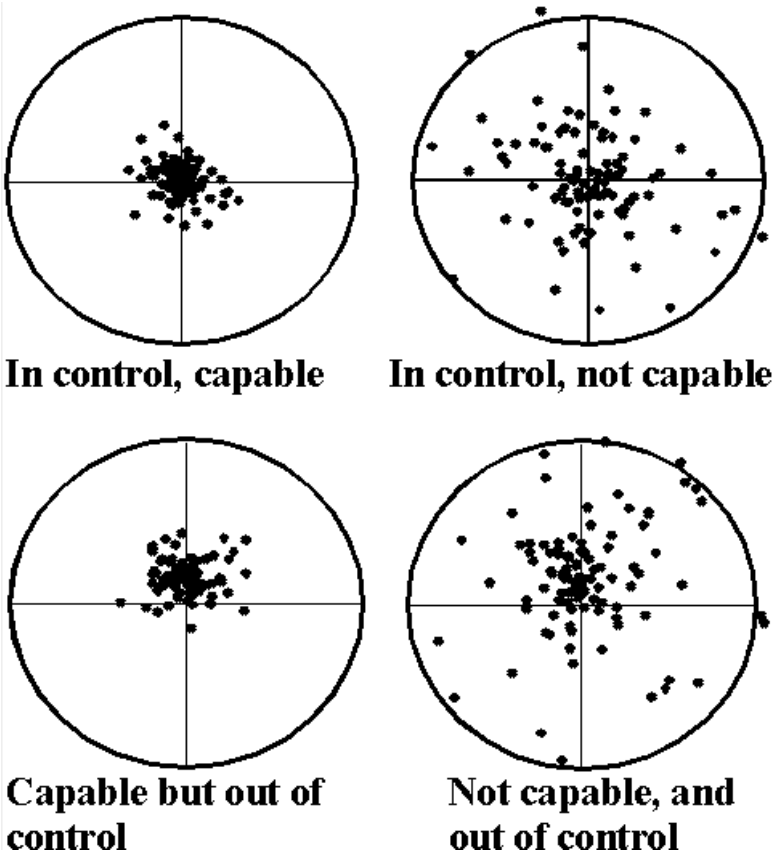


Accuracy, precision… and resolution…

Accuracy, precision… and resolution…

Precision: ability to reproduce a reading (not necessarily correct);

Accuracy: deviation (or error) of reading from a true value;



Capable -> precise

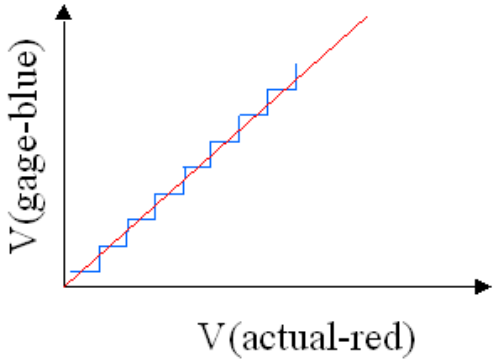
In control -> accurate

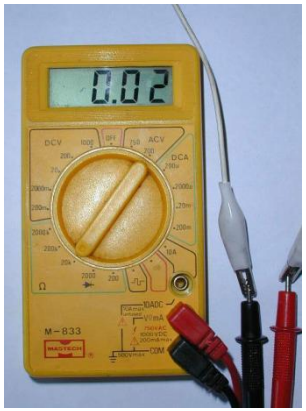
Accuracy, precision… and resolution…

Digital VM

Instrument Capabilities
DVM - Digital Voltmeter
Assume ~ 8 bit DVM with 0-10 volt scale

Resolution: $\frac{10 \text{ Volts}}{2^8} \sim 0.04 \text{ Volts}$

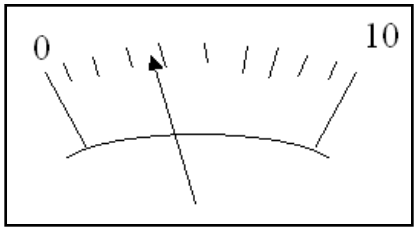




0.04 Volts is the "Least Count". This term usually has more significance on an analog meter.

Analog VM

Resolution:



Range… gain…

- **Range**: minimum and maximum voltages
  - Smaller range → more precise representation of signals (for a given digital resolution)
- **Gain**: amplification or attenuation of a signal for best fit in range

Fundamental concepts: basic quantities

- **Length**: describes size of a physical system - UNITS!!
- **Time**: is understood as a succession of events
- **Mass**: property of matter used to compare interaction between bodies
- **Force**: measure of interaction between bodies. Newton's laws

  Examples include:

  - Gravitational
  - Electrical and magnetic
  - Thermally induced

  Characterized by their: magnitude, direction, and point of application !! **VECTORIAL QUANTITY**

Fundamental concepts: basic quantities

- **Work**: force × distance. Scalar quantity
- **Power**: (force × distance) / time. Scalar quantity
- **Etc**…

Reading assignment

- **Holman (required):** Ch. 1,
  Ch.2: sections 2.1 to 2.6

- **Bishop (recommended):** Ch. 1, 2

Homework assignment

- **Holman (required):** Review questions: 2.1, 2.2, 2.3
- **Bishop (recommended):** E1.2, E1.3, E1.4, P1.3