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CIE616 – Experimental Methods in Structural Engineering and Structural Dynamics

http://civil.eng.buffalo.edu/cie616

Lecture #8

Principles of Data Acquisition

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Data Recording and Acquisition

A: Analog

B: Digital

A: Analog Data Recording and Measuring

a) Meters.

b) Cathode ray oscilloscope.

c) Chart recorders.

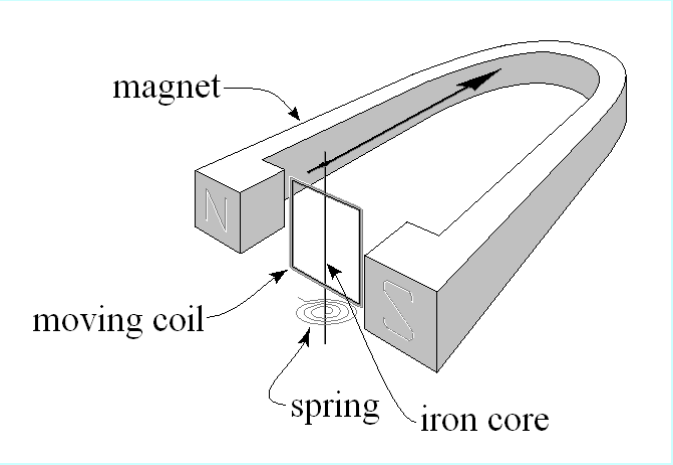
d) Ultraviolet recorders.

e) Magnetic tape recorders.

f) Frequency analyzers* (combined analog and digital).

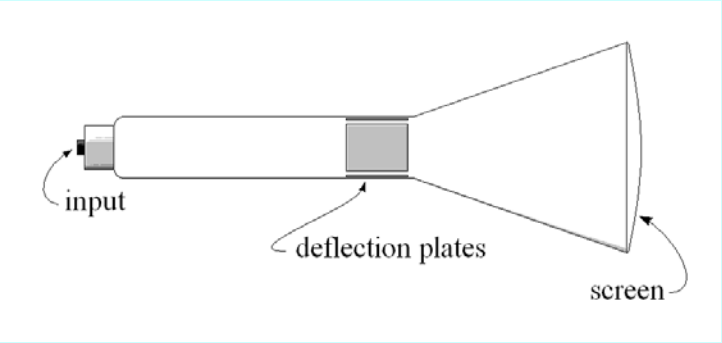
a) Meters

- mechanical
- moving coil
- moving iron
- electromagnetic
- induction meters
- electrostatic

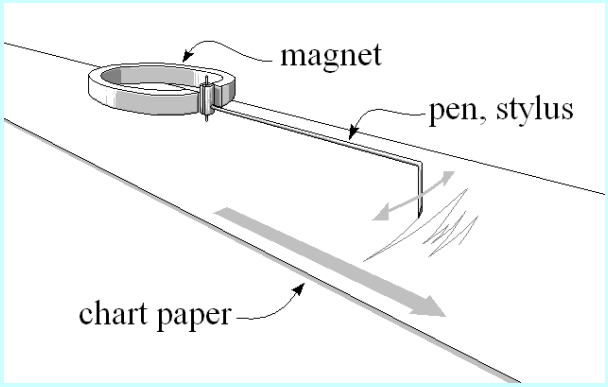


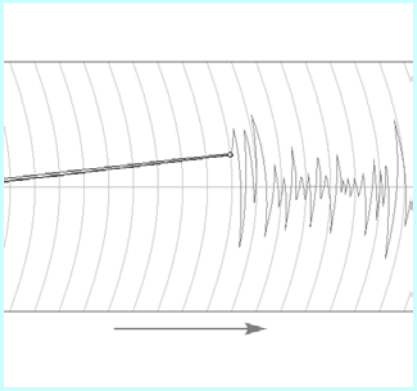
b) Oscilloscope

- x, y, inputs
- multiple channels
- time base
- x, y, display
- single ended inputs
- differential inputs

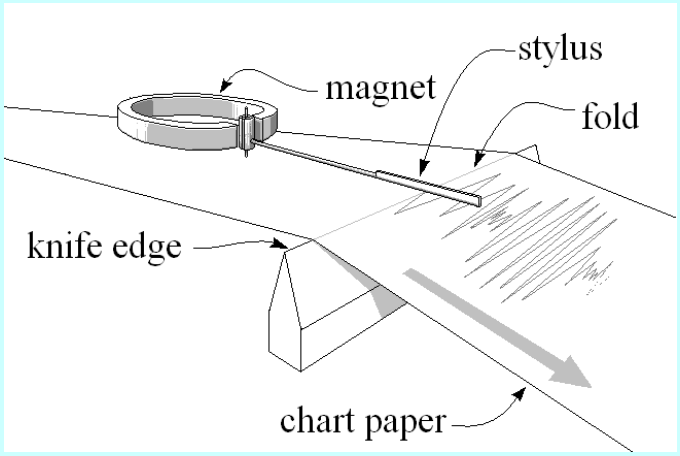


c) Chart recorders





- circular motion, need special paper



- knife edge stylus – linear recording

*Note: Dynamic response reduces range of recorders.

d) Light or laser recorders

- paper sensitive to light
- moving light beam
- extended frequency range

e) Magnetic tape recording

- high frequencies
- high resolution (fidelity)
- magnetic modulation of data
- requires complicated recording devices
- can be used with strip chart recorders

f) Frequency analyzers

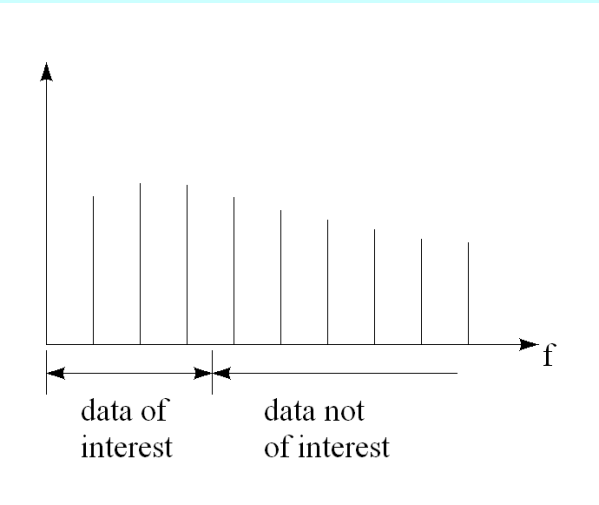
- analog data input
- converts data to digital signal
- performs FFT. in high speed boards. (10μsec – 256 points)
- performs averaging and display

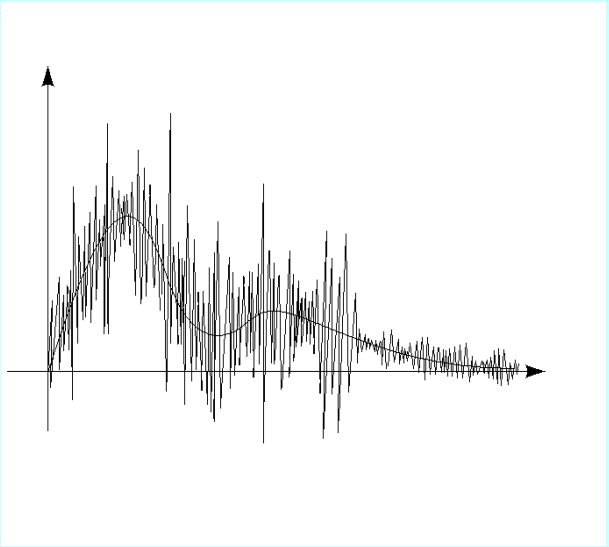
∴ Input signal (analog) → FFT + Avg. → Plotter (analog)

- FFT: Use binary formulation.
  (N initial points→N/2 frequency points)
- Uses short data frames with conversion/transformation to frequency domain $f_{n,\max} = 2\Delta f\ T\ s$ where T = period of time record, s sampling rate, Δf frequency resolution desired
- Displays single transforms or average transform → P.S.D.
- Determines transfer functions

Prefiltering of Analog Data

Low pass filtering

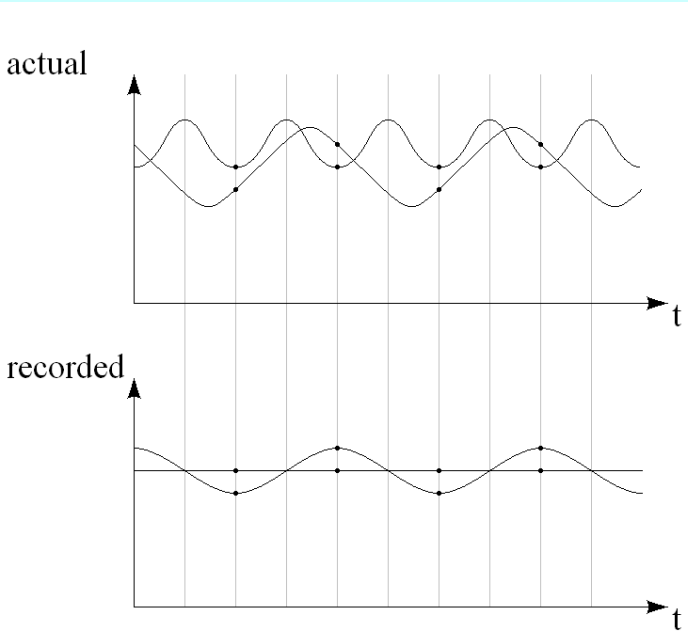




Aliasing

http://www.ni.com/swf/presentation/us/sampling/

Time domain



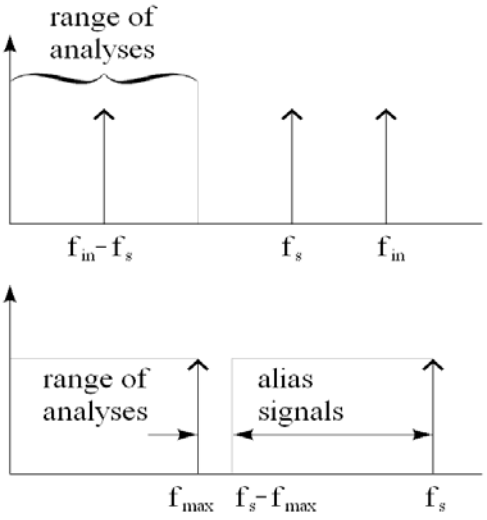
Frequency domain

$$2 f_{n,\max} = \Delta f \; T \; s = \Delta f \; N$$

T time duration of record
s sampling acquisition rate

$$f_{\min} = \Delta f = \frac{2 f_{\max}}{Ts} = \frac{2 f_{\max}}{N} = \frac{1}{N \Delta t}$$

N number of samples collected in one window



Suggested $s > 2f_{max}$ $s > 3f_{max}$ $s > 5f_{max}$
http://www.ni.com/swf/presentation/us/sampling/

B: Digital Data Acquisition

1) Principles

2) Microcomputer based data acquisition

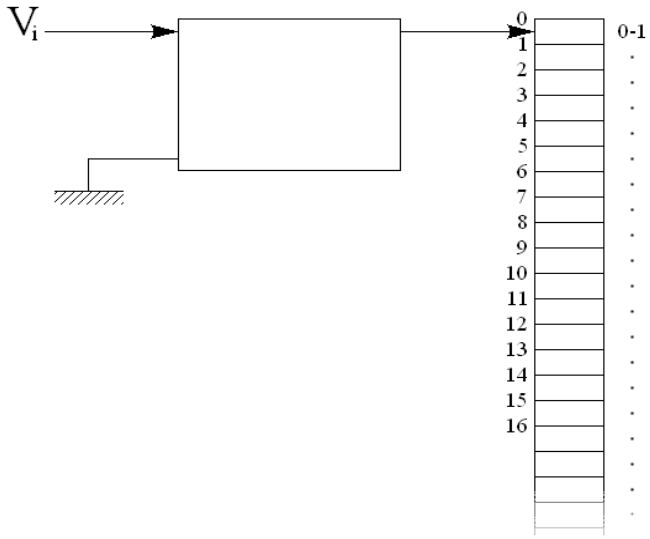
3) Programming

4) Labtech notebook

5) Interfaces

1) Principles

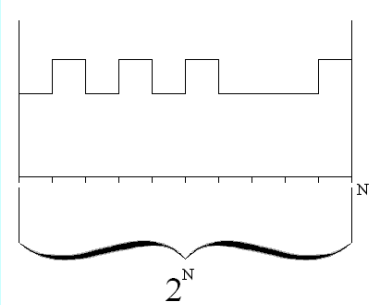
Analog to digital conversion



Maximum number:

$2^{N_{BIT}}$

N_{BIT} is the number of bits



Each bit is used for some information

- trigger
- clock operation
- direct memory access
- codes
- gains
- channel address
- …

Buffer

- each channel has its own buffer
- buffer size is in terms of samples
- each sample takes 2 bytes
  (e.g. 10 K samples = 20 Kbytes

Digital input

Thermocouple input

Counter

Time measurement

Calculated channels

x, y and parameter γ

x + y, $x\gamma$, $\int x$, $\frac{dx}{dt}$, EFT(x), statistical...

Digital filtering, …, Calibration – nonlinear input…

Process control

Waveforms - text editor

- notebook

-Quattro/ Lotus

2) Microcomputer based data acquisition

- Addresses and registers are controlled by computer logic
- A / D (or D / A) is controlled by DAQ board
- You can select from the computer and send to board
  - channel / module / chassis destination
  - rate of conversion (sample rate)
  - gain of signal
  - storage (memory address)
- Programming language
  - G-Language based (icon) language (LabView)
  - Basic programming languages
    - Q basic
    - Fortran
    - C, etc…

- Requirements:
  - set board parameters (i.e. address, etc…)
  - initiate parameters for acquisition or control
  - retrieve data (or send data)
- Parameters to initiate
  - single or sequential information (loops in LabView)
  - channel gain (in conditioner and board configuration)
  - trigger type (in LabView is automatic)
  - clock settings
  - channel sequence
- Buffer
  - each channel has its own buffer
  - buffer size is in terms of number of samples
  - 1 sample = 2 bytes
    (i.e. 10 K samples = 20 Kbytes)

How to choose data acquisition boards

- Software for acquisition
  - National Instruments - LabView
  - LabTech Notebook for Windows
  - Pacific Instrumenta

- Software for analysis
  - Spreadsheets (Excel, Quattro-Pro, etc…)
  - Matlab
  - LabView*

3) Programming

- Use regular computer languages (for PC use basic language (Microsoft Q Basic or Equik) (can use Fortran, C-Compiler, etc…))

- Require
  a) set of board's parameters (i.e. address, clear, stop).
  b) initiate parameters for acquisition or control
  c) retrieve data (or send data)

- Parameters to initiate
  a) single or sequential information
  b) channel gain
  c) trigger type
  d) clock settings
  e) channel sequence

- Require
  a) low byte - integer
  b) high byte - integer

  high byte = $(value/256)_{integer}$ noting that $256 = 2^8$

  low byte = $(value-256 * high)_{integer}$

Example of DAQ: Pacific Instruments

Example of DAQ: Nat'l Instruments: Lab View