Data Acquisition (DAQ) MEC100x-Lectures 9

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Aims

1. Why data acquisition system?
2. Many type of DAS
3. National Instrument (NI) DAS
4. Advantech DAS
5. DAS Connection with MATLAB

What is Data Acquisition (DAQ) ?

What is Data Acquisition (DAQ)?

Acquisition: Collecting-gathering data from real world/Physical environment:

- **DAS is an interface between sensor and computer.**
- **The basic function of DAS is to convert analogue signal coming from sensor to digital via A/D converter and fed to computer.**

Data acquisition (commonly **abbreviated as** **DAQ or DAS**) is the process of sampling signals that measure **real-world physical quantity** and converting them into a digital form that can be manipulated by a computer and software.

In Data Acquisition; signals are converted from the analog domain to the digital domain and then recorded to the ROM, flash media, or hard disk drives.

What Does a Data Acquisition System Measure?

Data acquisition systems are **measuring physical phenomena** such as:

- **Temperature**
- **Voltage**
- **Current**
- **Strain and Pressure**
- **Shock and Vibration**
- **Distance and Displacement**
- **RPM, Angle, and Discrete Events**
- **Weight: load cells**

- There are several other measurements, including **light and images, sound, mass, position, speed, etc.** that can be measured by the data acquisition system.

The Purposes of Data Acquisition

The data acquisition instrumentation is also used **in monitoring applications**.
Such examples are:

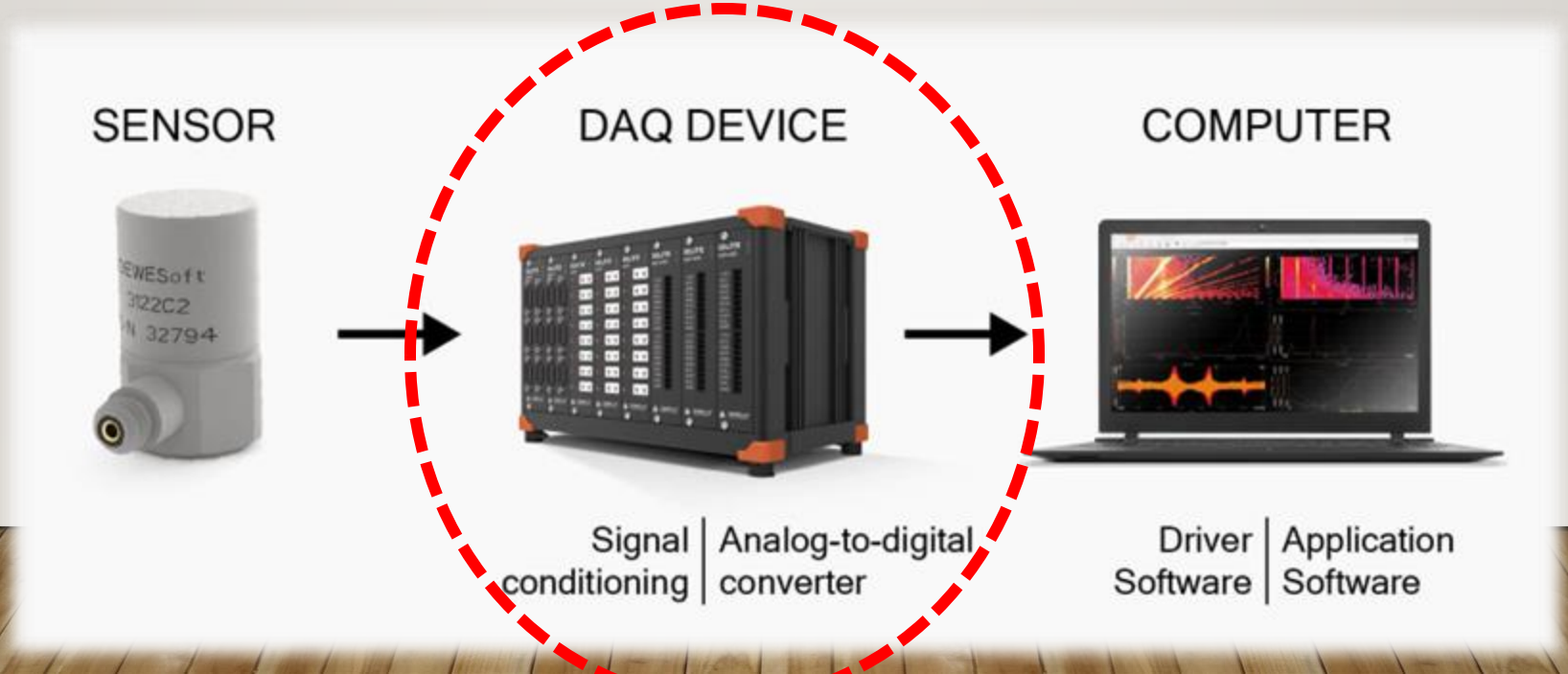
- Monitor **the condition of complex machinery** such as **generators, motors, fans, etc.**
- Monitor **structural properties** of buildings such as bridges, stadiums, etc.
- Monitor **energy consumption** and energy efficiency in the production process.
- And many other monitoring scenarios.

Components of Data Acquisition System

Modern digital data acquisition systems consist of **four essential components** that form the entire measurement chain of physics phenomena:

- **Sensors**
- **Signal Conditioning**
- **Analog-to-Digital Converter**
- **Computer with DAQ software for data logging and analysis**

The typical data acquisition system has multiple channels of signal conditioning circuitry which provide the interface between **external sensors and the A/D conversion** subsystem.

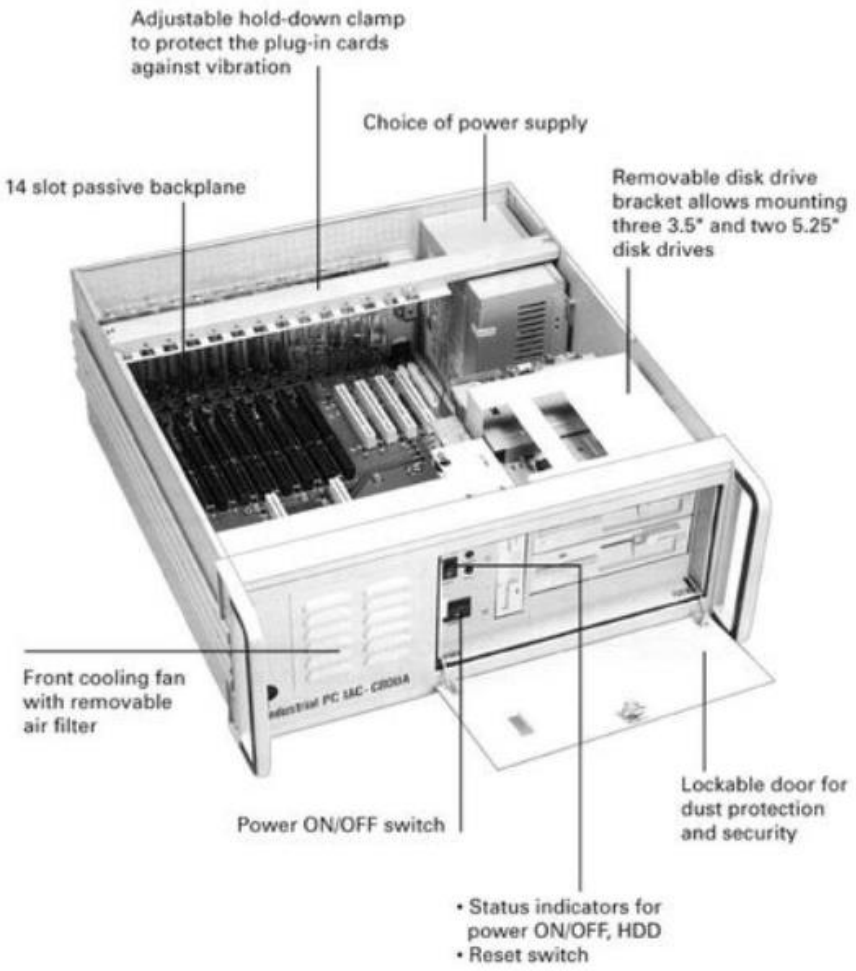


Components of Data Acquisition System

A DAQ system consist of **hardware and software** that form the entire measurement chain of physics phenomena:

- **Sensors**
- **I/O terminal panel(s)**
- **Computer with DAQ board for data logging**
- **Computer with DAQ software for data logging and analysis**

Inside the Case of a Computer



It contains a system board (mother board). This board hosts most of the circuits connecting :

CPU,
memory,
I/O ports.
buses,
expansion slots,
storage
Power supplier

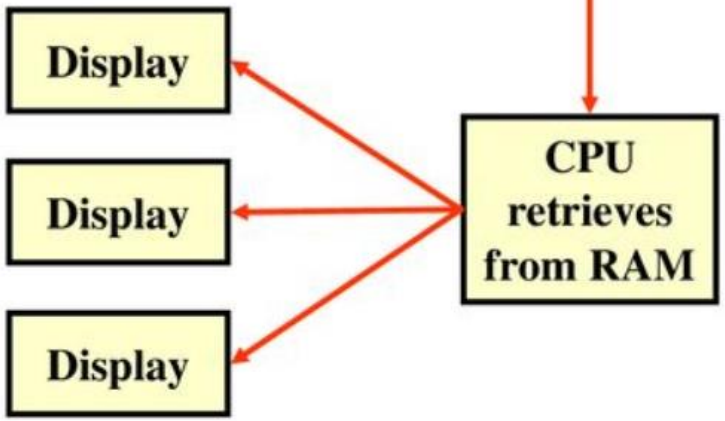
Plug-In Data Acquisition Boards

Plug in data acquisition board is a good solution for systems that don't need portability.

Key Benefits

- Lowest cost
- Large selection to choose from
- Established platform

Computer Data Acquisition Board



A plug-in data acquisition board is inserted directly into computer's bus and transfer data directly to computer's memory.

It utilizes computer hardware:

- cables & buses
- power supply
- back panel, *etc.*

It is designed for particular bus structure, and unaffected by computer's internal electrical noise.

Bus Structures of Plug-in Board

The are several types of local bus structures commonly used for plug-in boards :

- **AT**
- NEC PC-9800
- Parallel Port
- **PCI**
- **PCMCIA**
- PXI
- **USB**
- Others

DAS-8 Series

The DAS-8 family is a series of 4 kHz analog and digital boards for IBM compatible computers.

Major Models

- DAS-8
  base model, 8-channel, 12-bit
- DAS-8/LT
  modified model for laptop
- DAS-8PGA
  programmable inputs, clock
- DAS-8/AO
  include 2 analog output channels

Specifications of DAS-8PGA

Power consumption	+5 V supply	800 mA typ. /1 A max
	+12 V supply	2 mA typ. /5 mA max
Number of Channels	(DIP Switch)	8 single-ended/differential
Resolution		12-bit
Accuracy		0.01% of reading +/-bits
A/D Type		Successive approximation
Full scale range gain	+/- 5 VDC	(Default)
	+/- 10 VDC	0 to 10 VDC
	etc. (9 gains)	
Coding	Offest/True binary	Bipolar/Unipolar
Gain Tempco	+/- 50 ppm / C max	
Zero Drift	+/- 10 ppm / C max	
Acquisition time	4 μs to 0.1 %	Typ. full scale step input

The Purposes of Data Acquisition

The **primary purpose of a data acquisition system** is to acquire and store the data.

But they are also intended to provide real-time and post-recording visualization and analysis of the data.

Furthermore, most data acquisition systems have some analytical and report generation capability built in.

Engineers in different applications have various requirements, of course, but these key capabilities are present in varying proportions:

- **Data recording**
- **Data storing**
- **Real-time data visualization**
- **Post-recording data review**
- **Data analysis using various mathematical and statistical calculations**
- **Report generation**

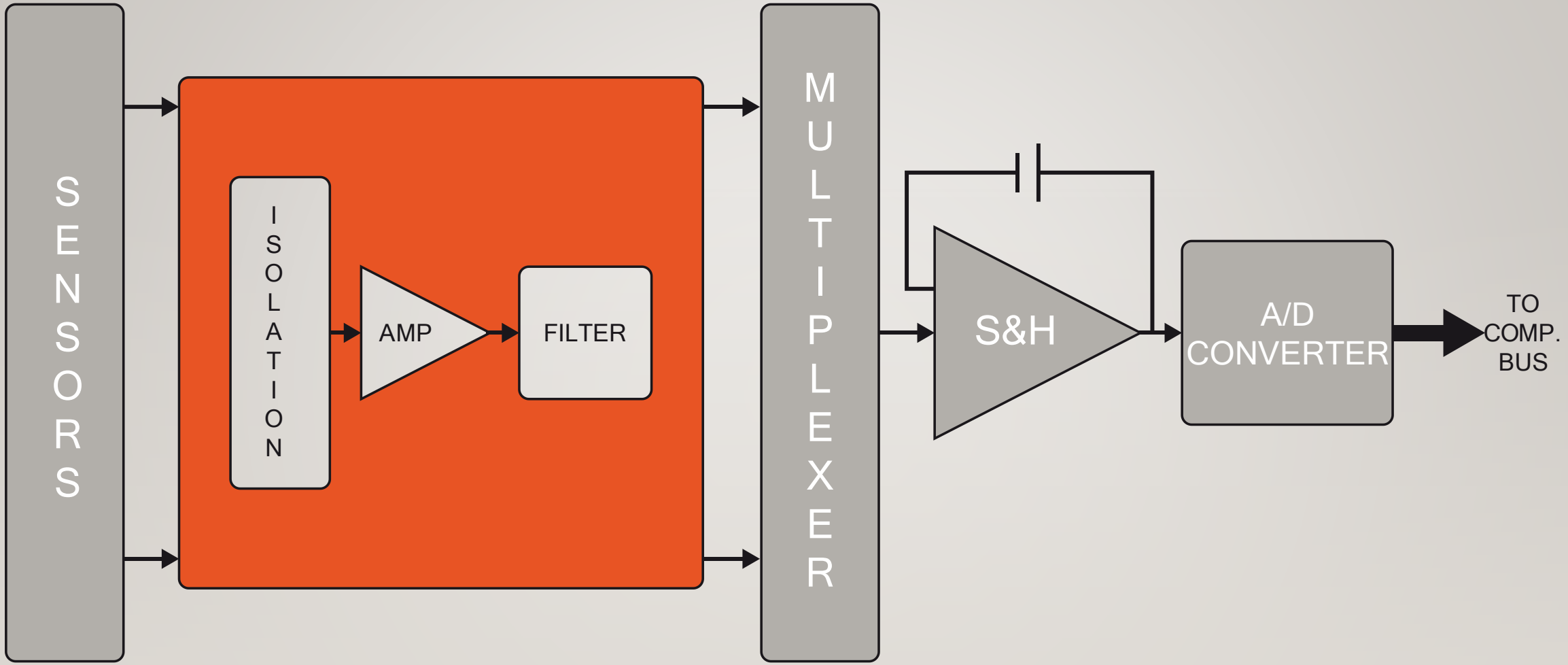
THE MEASUREMENT PROCESS

- Data acquisition is the process of **converting real-world signals to the digital domain** for display, storage, and analysis. Because physical phenomena exist in the analog domain, i.e., the physical world that we live in, they must be first measured there and then converted to the digital domain.

- This process is done using **a variety of sensors and signal conditioning circuitry.**

- The outputs are sampled by analog-to-digital converters (ADCs) and then written in a time-based stream to a digital memory media, as mentioned above.

The Measurement Process

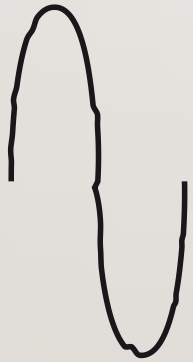


A complete scheme of an analog data acquisition system

Signal Conditioners

Signal conditioners are in the business of taking the output from analog sensors and preparing them to be sampled digitally.

If we continue the example of the thermocouple. The signal conditioning circuitry needs to linearize the output from the sensor as well as provide isolation, and amplification to bring the very small voltage up to a nominal level for digitizing.

Signal Source	Sensor (transducer)	Signal Conditioning	Analog-to-digital converter	Driver Software	Application Software
				00101001 01001011 10001011 10110101 10001011 01001011 00101001 01001011	12.256 lbf 43.643 lbf 67.873 lbf 84.299 lbf 62.916 lbf 33.009 lbf
Physical phenomena	Noisy electrical signal	Conditioned signal	Digitalized and sampled data	Raw binary information	Processed data

Sensors or Transducers

The measurement of a physical phenomenon, such as the temperature, the level of a sound source, or the vibration occurring from constant motion, begins with a sensor. A sensor is also called a transducer. A sensor converts a physical phenomenon into a measurable electrical signal.

Sensors are used in our everyday lives. For example, the common mercury thermometer is a very old type of sensor used for measuring temperature.

So other types of sensors have been invented to measure temperatures, such as **thermocouples, thermistors, RTDs (Resistance Temperature Detectors),** and even infra-red temperature detectors.

Millions of these sensors are at work every day in all manner of applications, from the engine temperature shown on our automobile dashboard, to the temperatures measured in pharmaceutical manufacturing. Virtually every industry utilizes temperature measurement in some way.

There are many other **types of sensors** that have been invented to measure another physical phenomenon:

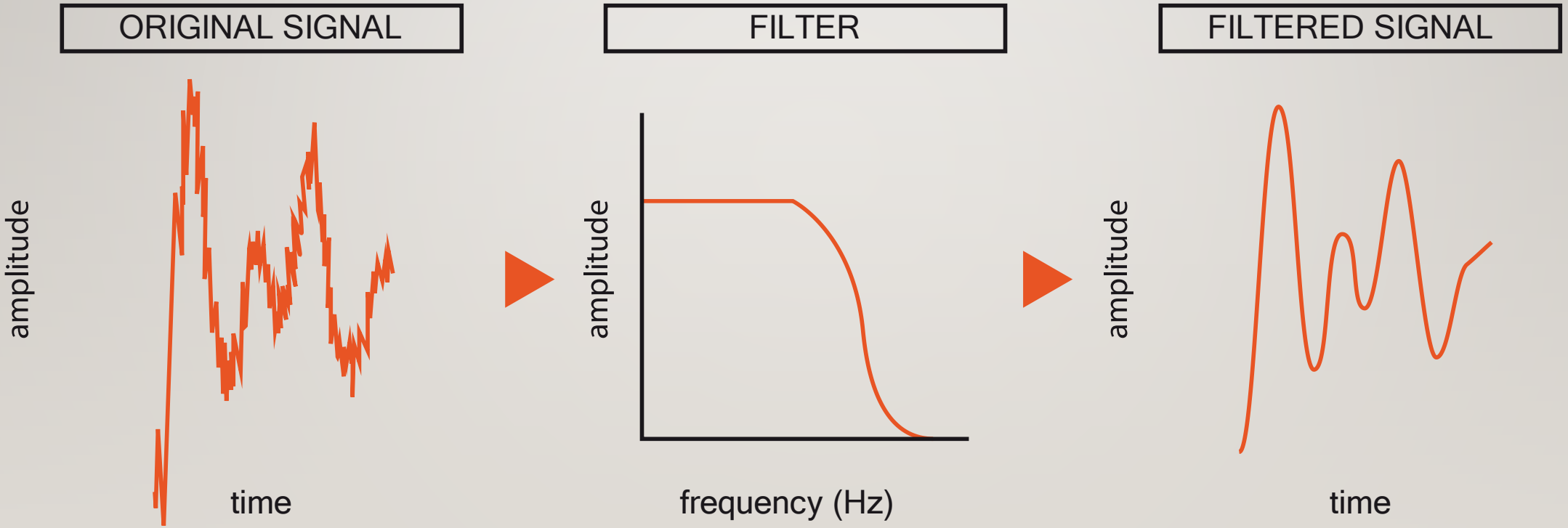
- **Load cells:** for measuring weight and load
- **LVDT sensors:** LVDTs are used to measure displacement in distance
- **Accelerometers:** measuring vibration and shock
- **Microphones:** for measuring sound,
- **Strain gauges:** to measure strain on an object, e.g. measure force, pressure, tension, weight, etc.,
- **Current transducers:** for measuring AC or DC current, and countless more.

Depending on the type of sensor, its electrical output can be a voltage, current, resistance, or another electrical attribute that varies over time.

The output of these analog sensors is typically connected to the input of a signal conditioner.

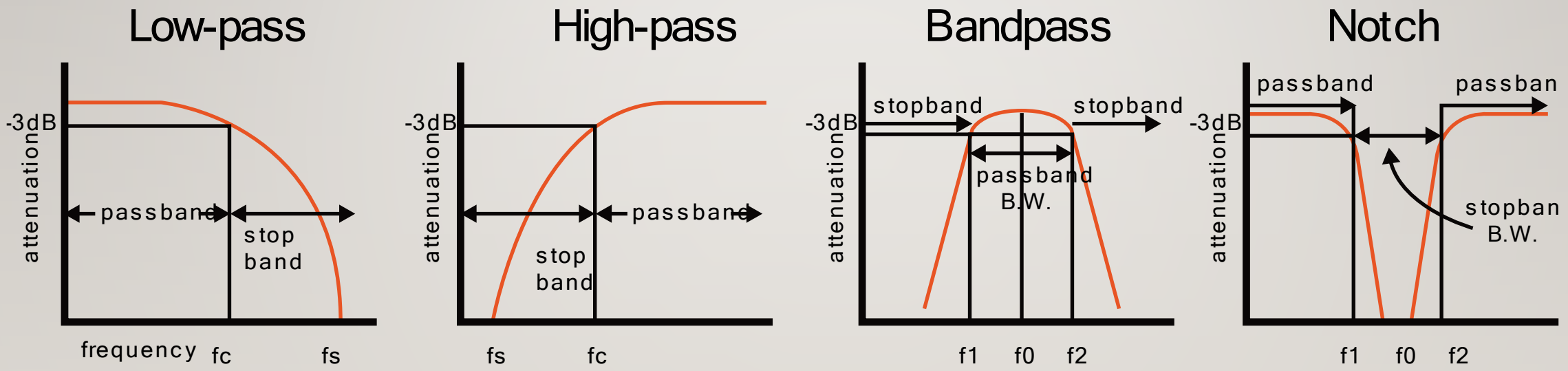
Filtering

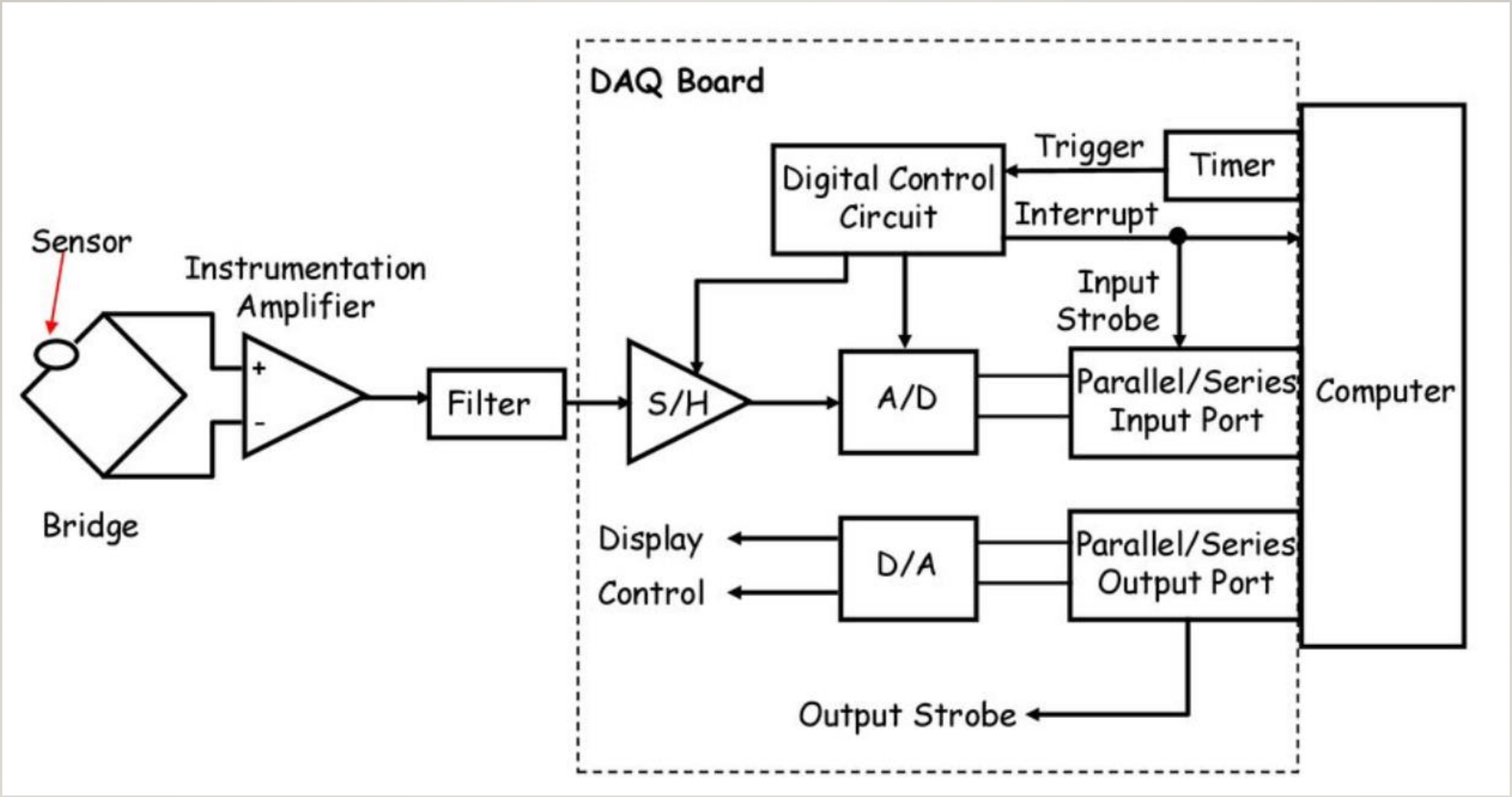
Virtually every signal that we want to measure can be affected by electrical interference or noise. This has a variety of causes, including ambient electromagnetic fields which can be induced into high gain signal lines, or simple voltage potentials that exist between the sensor or measuring system and the object under test. Therefore, the best signal conditioning systems provide selectable filtering that the engineer can use in order to remove these interferences and make better measurements.



Filters are normally expressed in terms of the band that they operate upon. There are four basic **types of signal filters**:

- **Low-pass filter:** this filter reduces or "rolls off" starting at a given frequency and those above it.
- **High-pass filter:** does the opposite and allows frequencies to pass which are above a given frequency.
- **Band-pass and band-reject filters:** either pass or stop (reject) frequencies between two given values.




DAQ Board
Digital Control Circuit
Trigger
Timer
Interrupt
Input Strobe
Sensor
Instrumentation Amplifier
+
-
Filter
S/H
A/D
Parallel/Series Input Port
Computer
Bridge
Display
Control
D/A
Parallel/Series Output Port
Output Strobe

DATA ACQUISITION SYSTEM PRICE

- Data acquisition systems are **sold by a variety of companies and are available with a broad range** of capabilities and specifications, thus the prices can vary significantly.
- It is useful to provide general pricing for these various levels of DAQ systems, using the price-per-channel model. Estimated prices are given in USD (US dollars):

- **Low-end DAQ systems** typically range from $200 - 500 per channel
- **Mid-range DAQ systems** typically range from $500-1000 per channel
- **High-end DAQ systems** typically range from $1000-2000 per channel

Thank You For Your Attention!

Any Question?