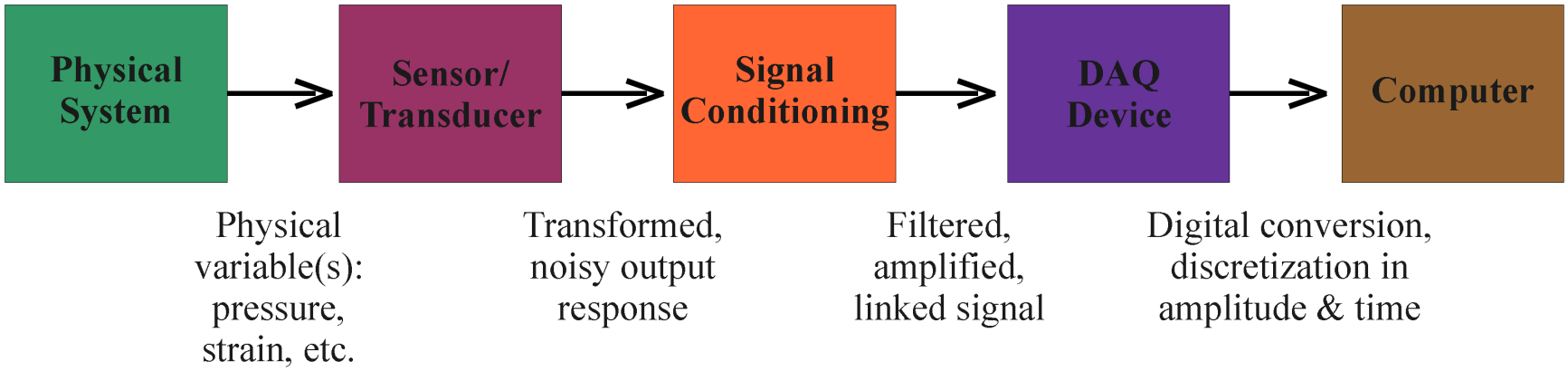
EMEM 280: Measurements, Instrumentation, & Controls

MIC Fundamentals:
Sensors & DAQ Concepts

John D. Wellin

Winter Quarter, 2005-2

Sensors & Computer-Based DAQ



Data Acquisition Device = specific hardware for connecting external voltage signals to a computer.

Data Acquisition System = entire collection of sensor, signal conditioning, DAQ device, and computer with associated software.

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Sensors & Computer-Based DAQ

A **sensor** is a device that measures a physical variable by **transducing** (generating) a correlated output response. The physical variable may be temperature, light intensity, flow rate, pressure, etc.

The immediate output response may be electrical, mechanical, optical or otherwise, but to be useful to the computer it must often be further converted to an electrical voltage signal by some means (also commonly referred to as the transducer stage).

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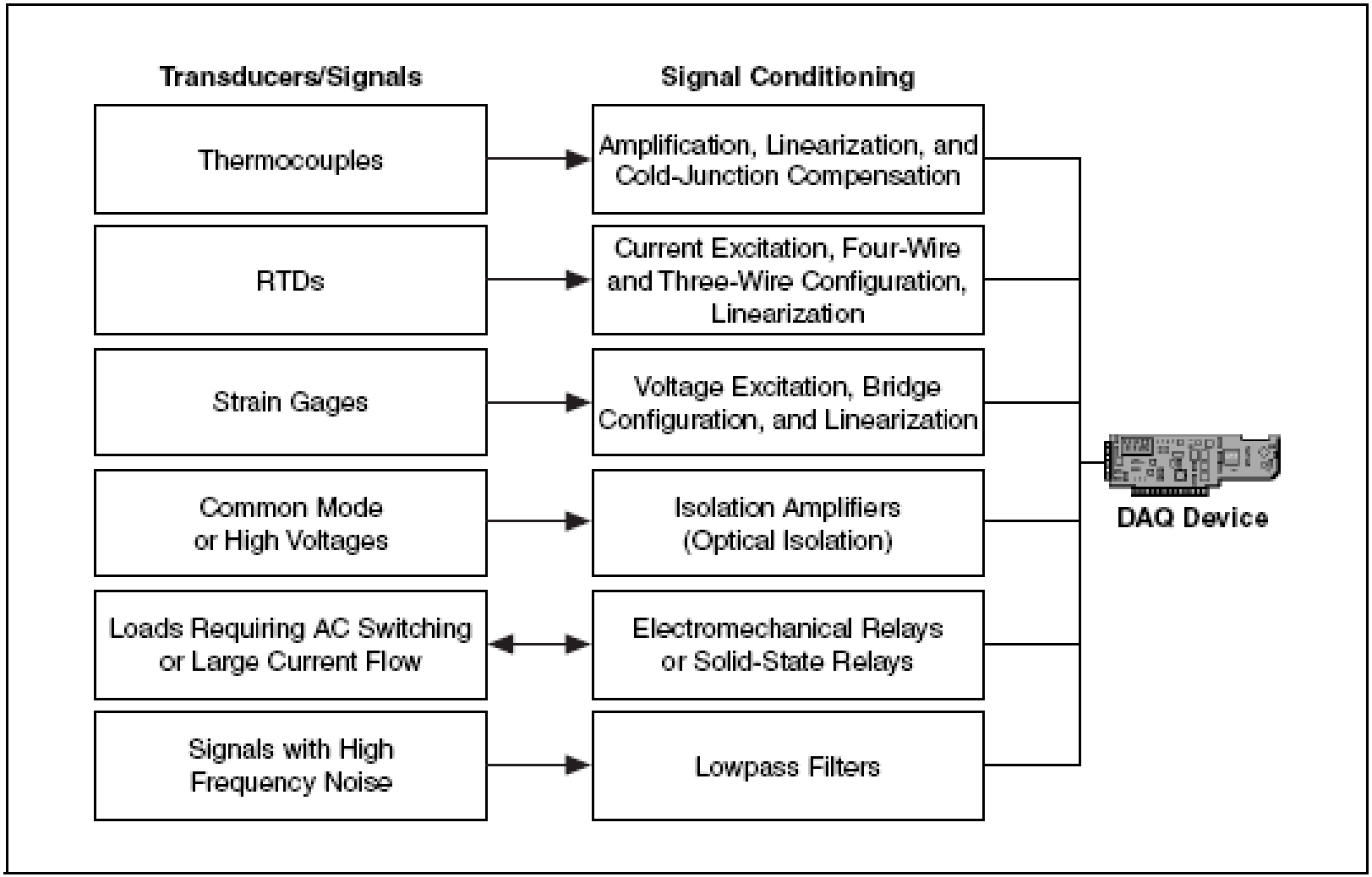
Sensors & Computer-Based DAQ

The DAQ device performs all final communications with the computer's digital environment. It has specific input voltage and timing characteristics that determine its ability to receive the signals.

In many cases, even after the sensor-transducer stage, additional **signal conditioning** is required to adapt the transduced voltage signals to the DAQ requirements. Conditioning may consist of amplification, filtering, excitation, isolation, etc.

Sensors & Computer-Based DAQ



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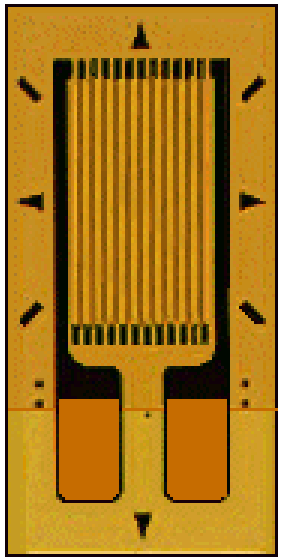
Sensors & Computer-Based DAQ

Note that not all signals and systems fall neatly into this delineation. In some cases not all of these steps are necessary, and in others all steps are combined into one cohesive unit that does everything.

Example: bonded metallic strain gage

Applied strain deforms the gage, lengthening the metallic conductor and changing its resistance—this is the sensor output response, which is **not** directly measurable. A Wheatstone bridge is commonly used to convert the resistance change to a voltage output. This is the transduced signal, which **can** be detected directly, but is usually a low-level signal (mV) that most DAQ's cannot reliably measure alone. Therefore an amplifier (and often a filter) is used between the Wheatstone bridge and the DAQ device.



Sensors & Computer-Based DAQ

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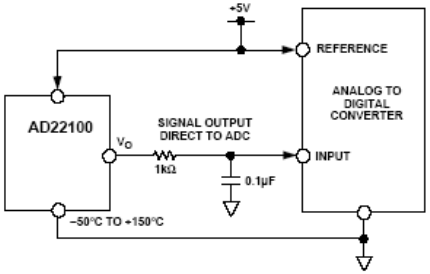
Example: PX482 Series current output pressure transducer from Omega Engineering

Requires excitation voltage high enough to source 4-20mA of current through the lead resistance, and a precision resistor arrangement to convert current to DC voltage at DAQ.

Example: AD22100 from Analog Devices

This voltage output temperature sensor with signal conditioning is a monolithic ASIC designed specifically for connection to an A/D converter.



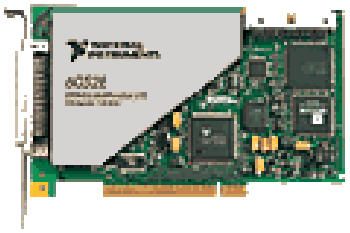
Data Acquisition Devices

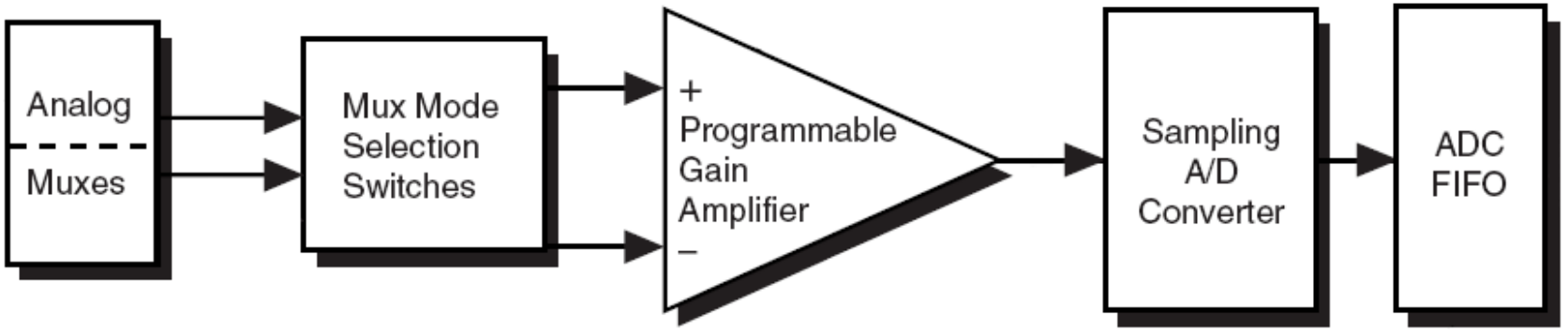
The DAQ device performs all remaining tasks required to interface the voltage signal to the computer:

- Coordinating and connecting multiple signals to the same computer – at multiplexer.
- Amplification, referencing, and common-mode rejection – at instrumentation amplifier.
- Analog-to-digital conversion – at A/D converter.
- Discrete time sampling – at A/D converter.
- Communication/control – via buffers, controllers, various buses and protocols.

Data Acquisition Devices

A multifunction DAQ device:
National Instruments PCI-6052E



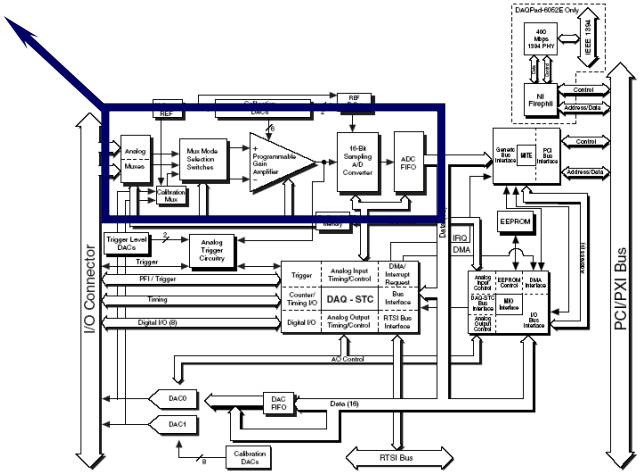


MUX = multiplexer (typically 2 or more where differential inputs are allowed).

PGIA = programmable gain instrumentation amplifier.

ADC = A/D converter.

FIFO = First-in first-out data buffer.



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Data Acquisition Devices

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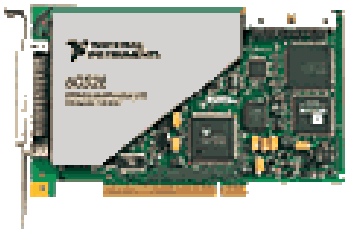

The word “multifunction” means that the device not only performs voltage inputs as previously described, but also other output functions.

Inputs are used for measurements, outputs for control.

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Multifunction DAQ Devices

Classification of functions:

- Analog Input (AI)

  Voltage values delivered to the DAQ device for conversion vary with infinite resolution over some input range. The general goal is to measure the variations as precisely as possible, as quickly as necessary.

- Analog Output (AO)

  Voltage values are generated at the appropriate DAQ device outputs, for connection to some proportional actuator or intermediate controller that is capable of creating some desired external effect.

Multifunction DAQ Devices

Classification of functions:

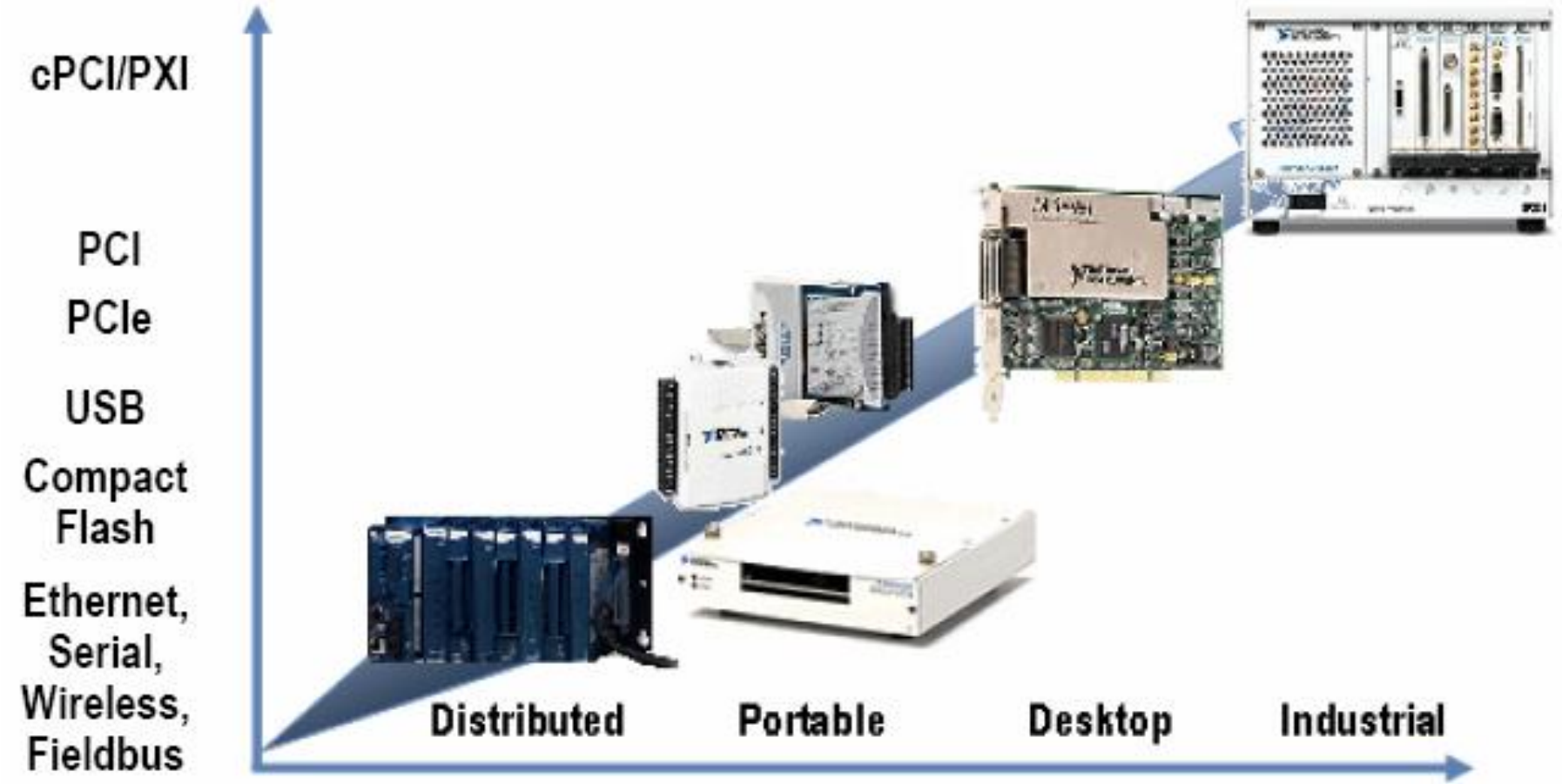
- Digital Input/Output (DIO)

  Discrete voltage values (high/low) are detected or controlled. Individual bits can be used to switch loads with relays, or determine on/off behavior. Combined bits can be used for more advanced communication.

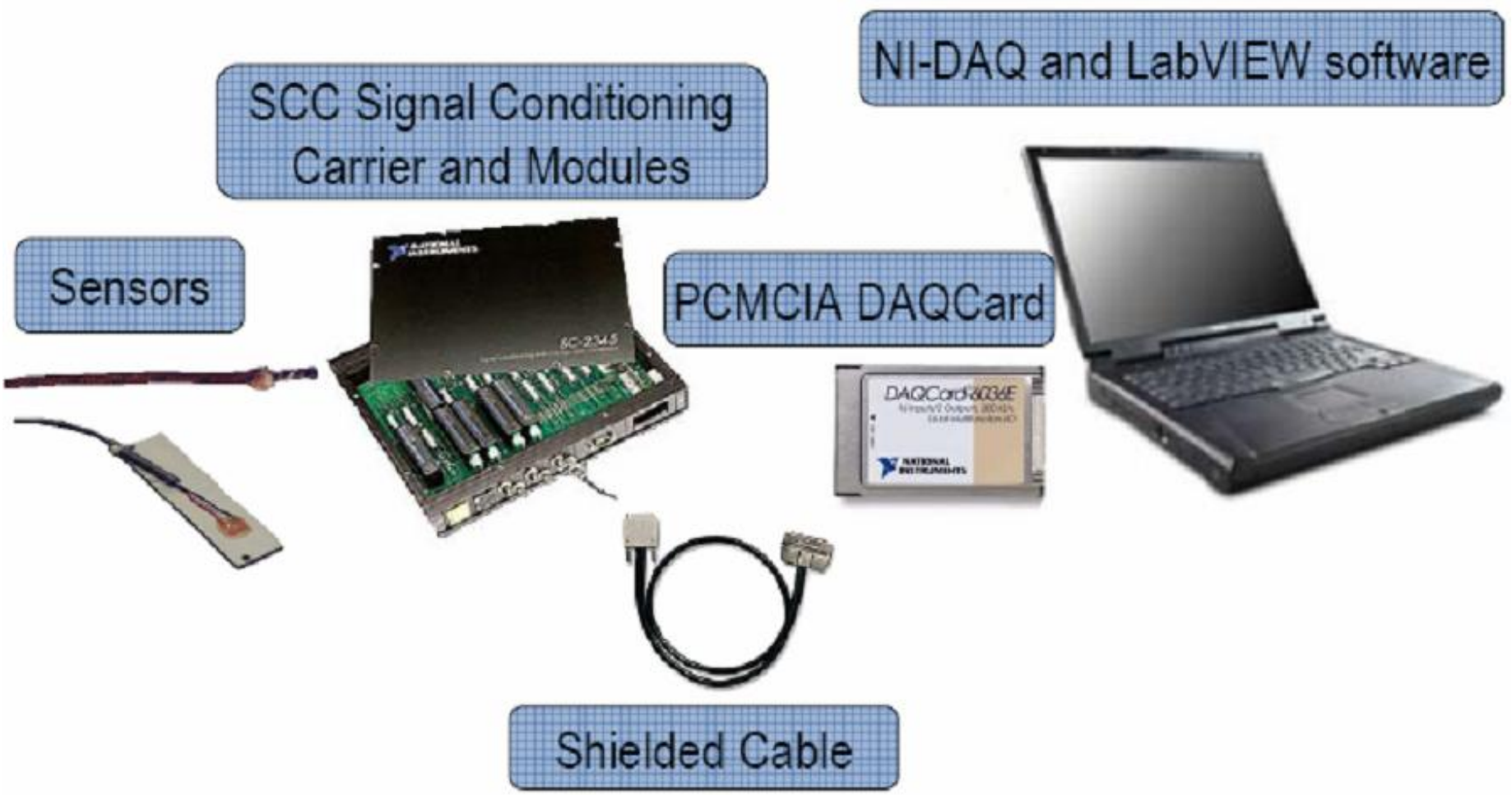
- Counter/Timer

  Repeating digital transitions can be detected or generated, for counting fast events, measuring frequencies, creating pulse trains for high-speed triggering, etc.

Multifunction DAQ Devices



DAQ Integration



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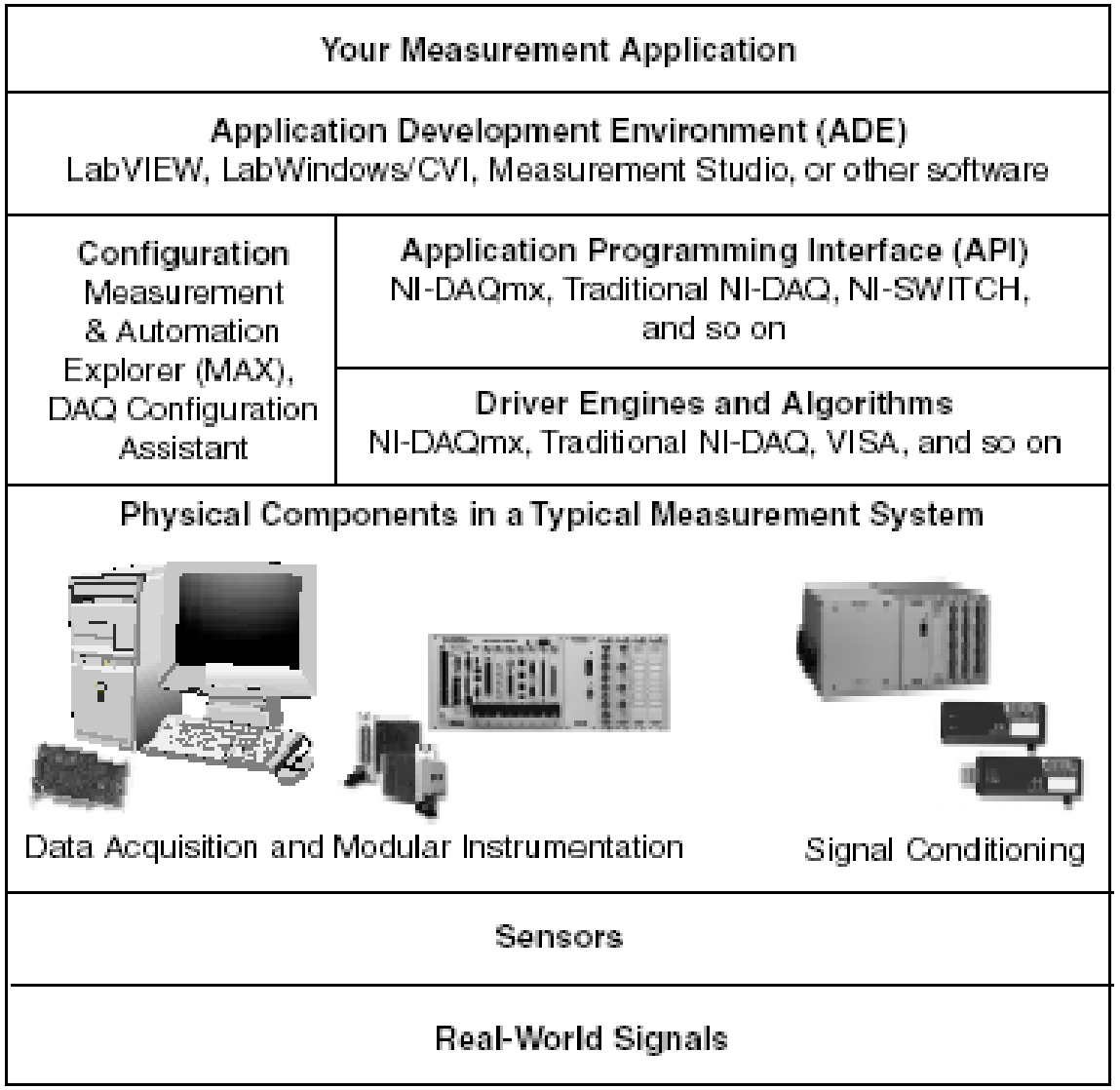
DAQ Integration

Development environment →

Configuration & basic hardware test interface →

DAQ device →



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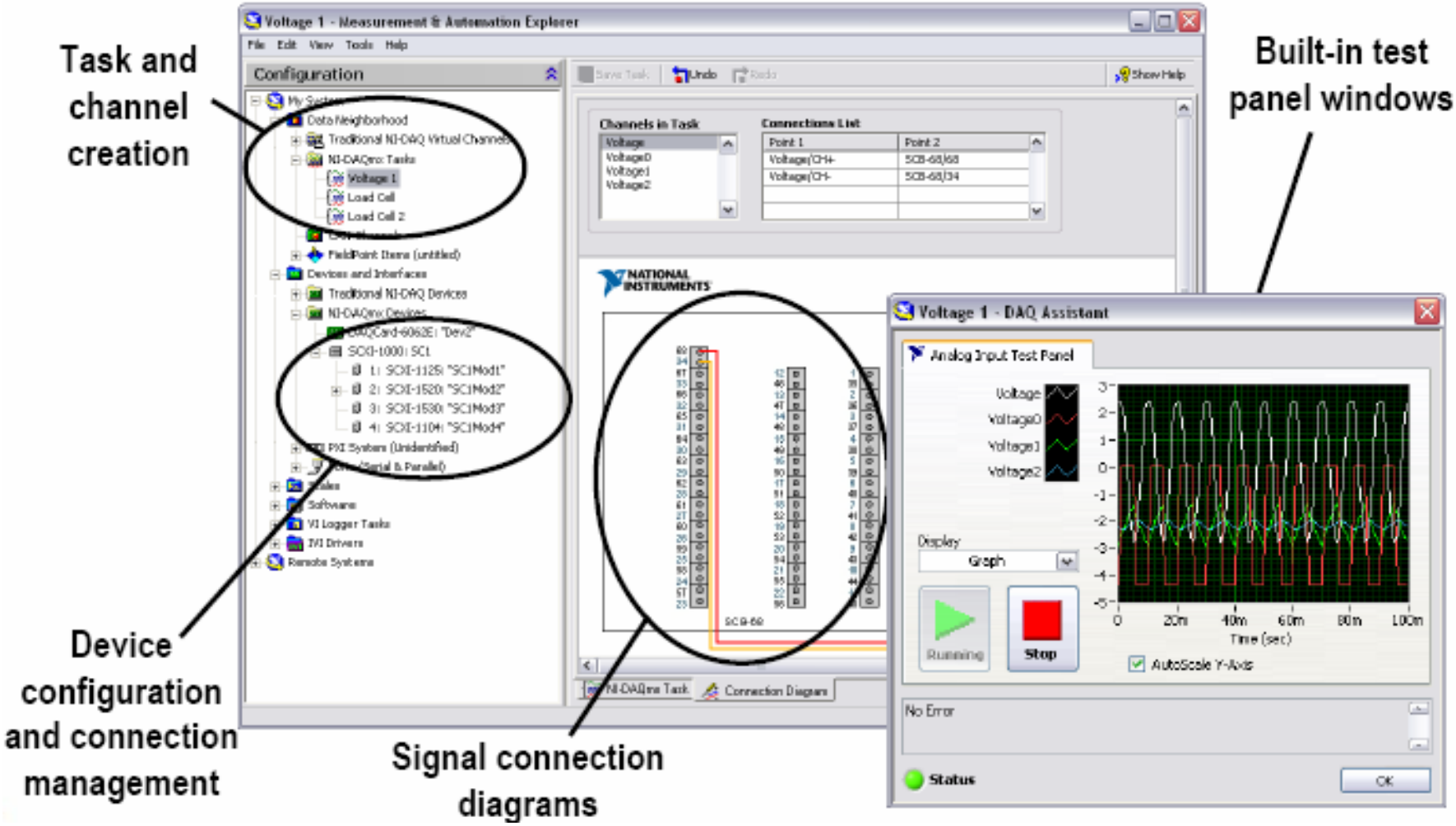
DAQ Integration

Measurement and Automation Explorer (MAX)



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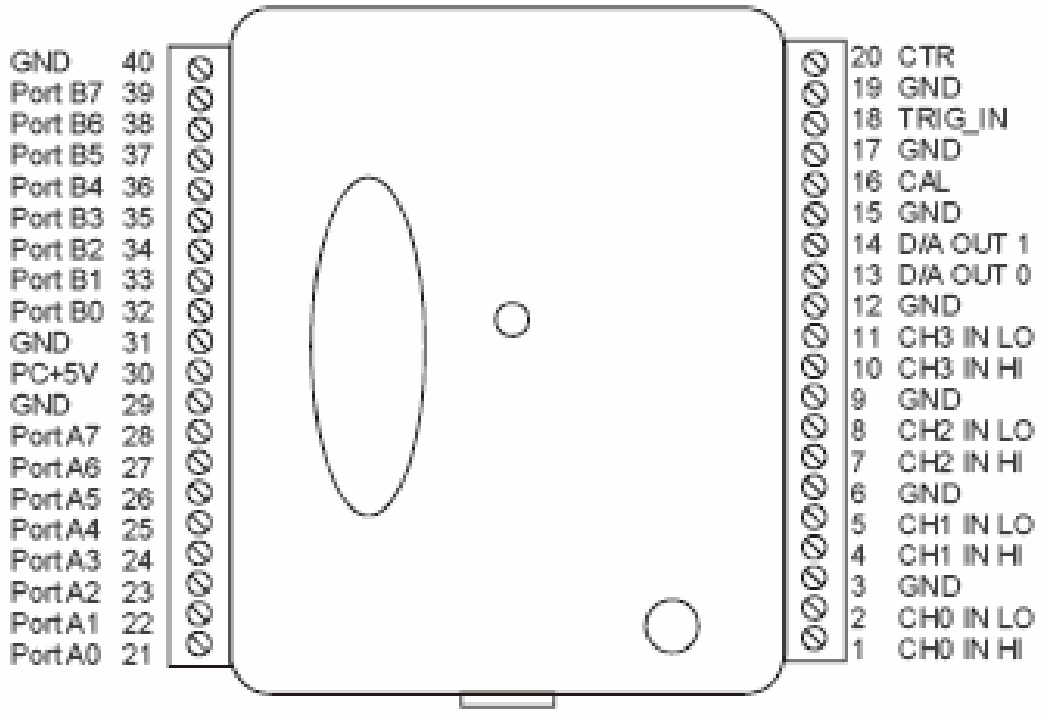
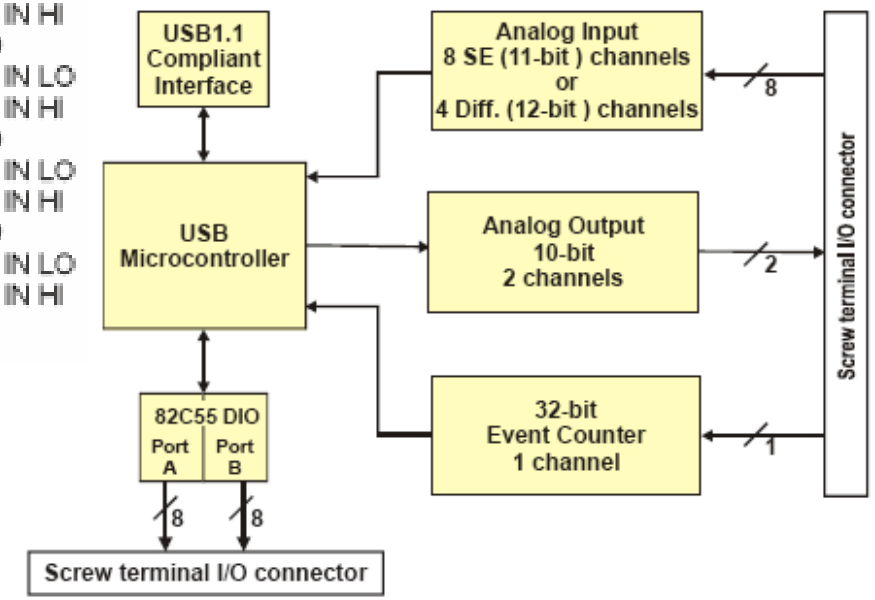
A Variation: USB-1208LS

From Measurement Computing





PMD-1208LS Functional Block Diagram

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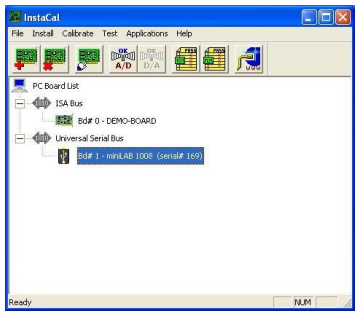
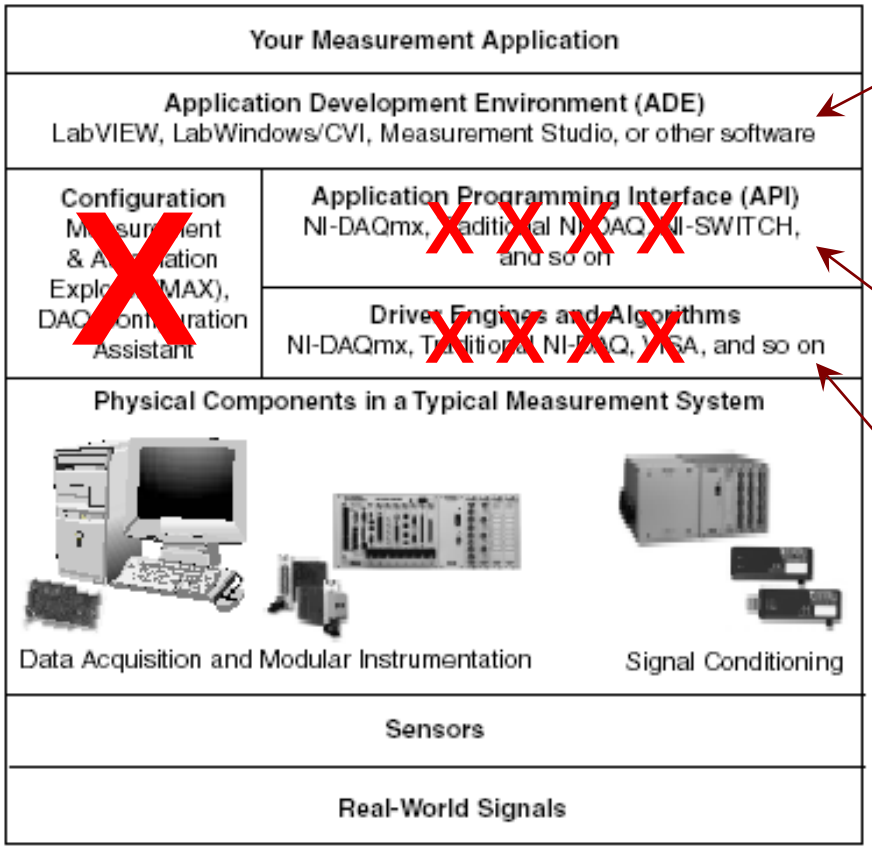
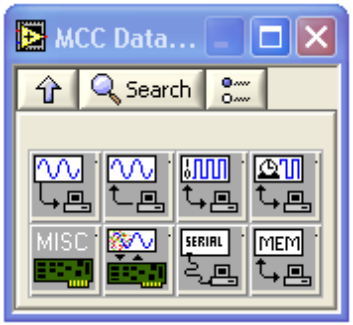
From Measurement Computing

LabVIEW "wrappers"

"InstaCal" (MAX not available)







"Universal Library"

Microsoft HID

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