ADVANCED INSTRUMENTATION

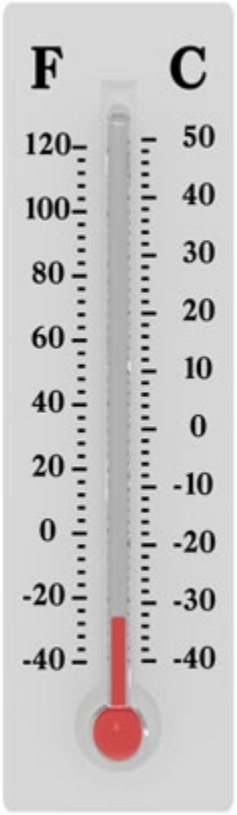
EE-434-F

What is Instrumentation?

Introduction

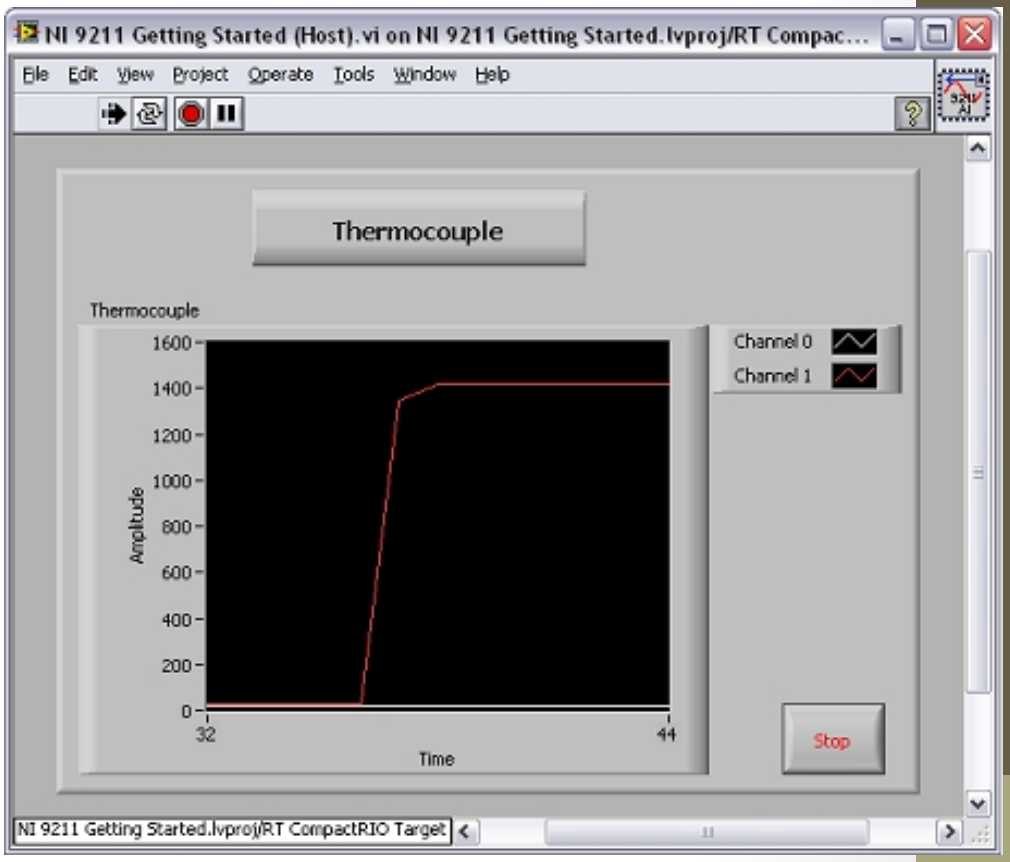
Simple Instrumentation

- Collecting data
- Manual measurements
- Slow sampling rates (1/10 Hz)
- Not controlling a process



Advanced Instrumentation

- Automated measurements
- Faster sampling rates
- Required for automated process control



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Simple Control Loop

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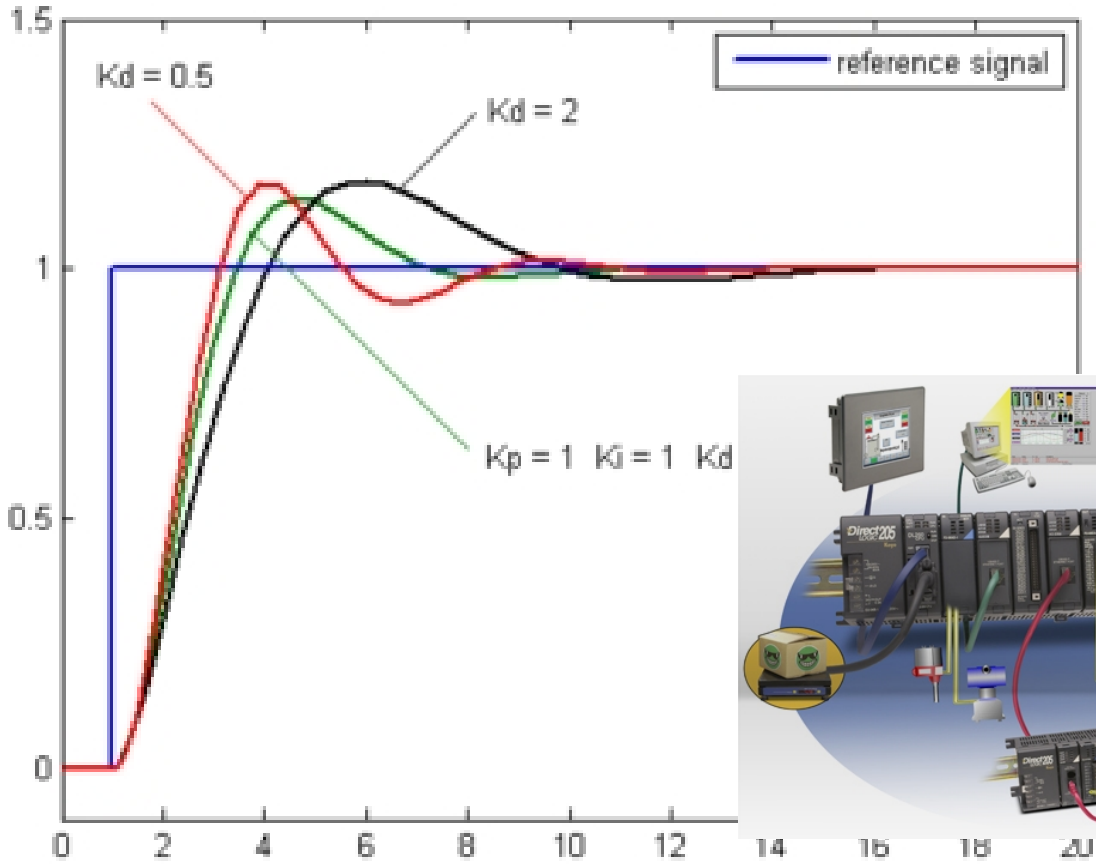
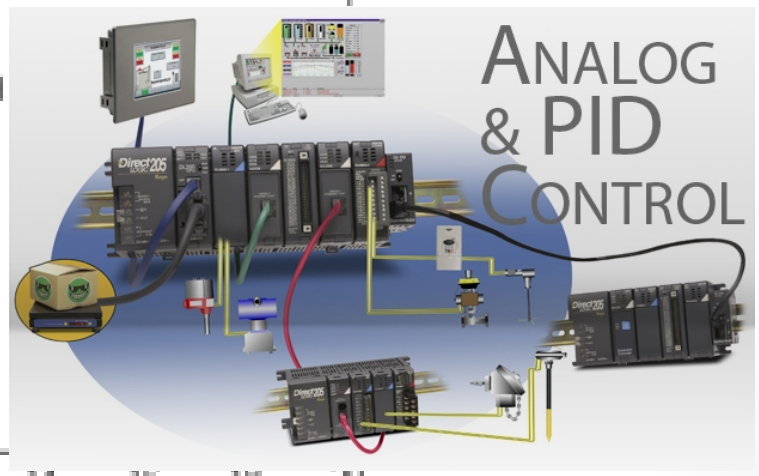
Advanced Control Loop





http://upload.wikimedia.org/wikipedia/commons/thumb/c/c7/Change_with_Kd.png/320px-Change_with_Kd.png

http://www.aboutplcs.com/directlogic/images/dl205_app_pid.jpg

Back to the Shower Example….

- Sampling Rate:
  - How often measurements are taken
  - Expressed as Hz
- Dynamic Range:
  - High measurement – low measurement
- System Response:
  - How long it takes for a change to take effect

http://epicthings.net/wp-content/uploads/2011/12/LED-temperature-shower-head.jpg

Back to the Shower Example…

- Linearity:
  - Does the response change correspond linearly to the control change?

    (y = mx + b)
- Measurement Error:
  - Measurement does not represent truth
- Disturbance/Impulse:
  - Unexpected step change

http://epicthings.net/wp-content/uploads/2011/12/LED-temperature-shower-head.jpg

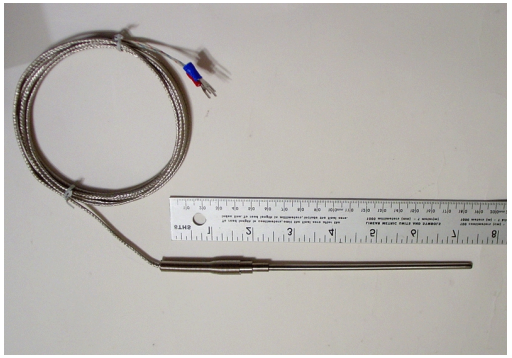
The Magic of Automation

- Physical phenomena are converted to voltage or current through a transducer (input)
- Control voltages or currents are converted into physical phenomena

www.futurlec.com

Besides Voltage:

- Voltage In:
  - Temperature
  - Pressure
  - Humidity
  - Detection of light
  - Etc.



www.auberins.com

- Voltage Out:
  - Warning Lights
  - Motors
  - Voltage controlled switches
  - Etc.

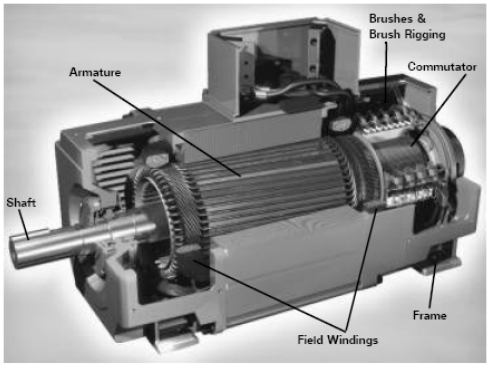


Figure 3-7. Major components of a DC motor (Courtesy of ABB Inc.)

http://www.globalspec.com

Control Loop

- Measurements + Logic = Control Loop
  - Compares current condition to set point
  - Adjusts to bring current condition to set point

- Ex: Cooling water for continuous reaction
  - Temperature must below T_H
  - Control a valve to increase cooling water flow rate

Iterative Improvements

- How can we make this process more accurate?
- How can we make this process more efficient?
- How can we make this process safer?

Increasing Accuracy

- Sample temperature in several places instead of just one, such that $T_{AVG} = T_1 + T_2 + T_3$

Increasing Efficiency

- Have a minimum temperature (T_C) so that valve closes when $T < T_C$

Increasing Safety

- Add leak detection: two flow meters, one on each side of the reactor, with flow rates F_1 and F_2.
  - If $F_1 = F_2$, no leak.
  - If $F_1 <> F_2$, leak is present, light warning LED.
  - Operator checks warning LEDs periodically.

Assignment

- What do you mean by ADVANCED INSTRUMENTATION

Functional block diagram of generalized Instrumentation system

INTRODUCTION

The term "instrumentation" has a multitude of different meanings to scientists in various fields of endeavour. To the physician, instruments are the tools of his trade; therefore, anything from an ear speculum, which is placed in the external ear to help visualize the eardrum, to a surgical retractor, which holds back the edges of an incision, is considered to be an instrument. The engineer is more specific in his or her use of the term "instrumentation".

We refer to instrumentation as those pieces of equipment that may be used to supply information concerning some physical quantity (usually referred to as a variable). This variable may be fixed and thus have the same value for a long time for a given physiological system, or it may be a quantity, that can change with time.

INTRODUCTION(contd.)

Instruments, therefore, are used to provide information about physiologic systems. In providing such information the instrument is carrying out an *indicating function. This function* may be achieved by a moving pointer on a meter, an aural or visual alarm, or by flashing numbers or words on a screen to describe the variable being measured. Many instruments not only indicate the value of a variable at a particular instant in time, but can also make a permanent record of this quality as time progresses, thus carrying out a *recording function as* well as an indicating function. Instruments that present the measured variable on a graphic chart, a computer screen, a magnetic or compact disk, or a printed page carry out the recording function. Today computers perform these functions by storing data in digital form on media such as semiconductor memory and magnetic or optical discs.

Functional block diagram of generalized Instrumentation system

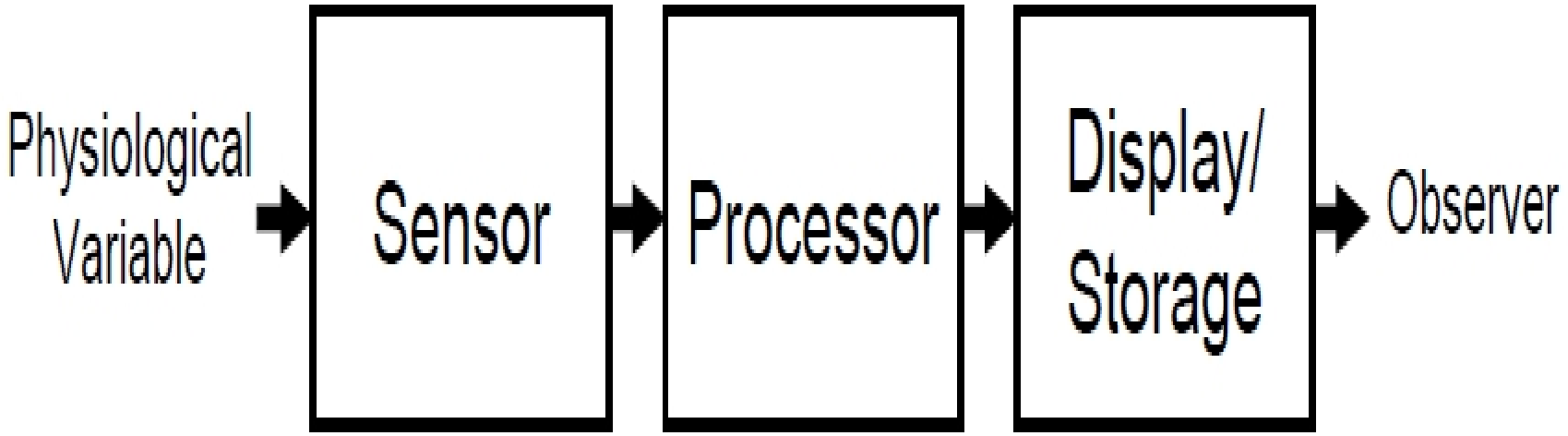
GENERAL INSTRUMENT SYSTEM

All instrumentation systems can be generally described by the block diagram shown in the figure.

The system consists of three different parts:

- the *sensor,*
- *the processor and*
- *the display* and/or *storage.*

Functional block diagram of generalized Instrumentation system(contd.)



Contd.

Sensor --The *sensor converts energy from one form to another, the second being related to the original* energy in some predetermined way. As an example, let us consider a microphone. Sound energy in the air surrounding the microphone interacts with this sensor, and some of the energy is used to generate an electrical signal. This electrical signal is related to the sound entering the microphone in such a way that it can be used to produce a similar sound at a loud speaker when appropriately processed. Thus, the microphone has acted as a transducer.

Assignment No.2

- Explain the Functional block diagram of generalized Instrumentation system

Functional block diagram of generalized Instrumentation system Cont..

There are three general requirements for transducers used in instrumentation systems.

These are:

1. Accuracy
2. Stability
3. Lack of interference with the physiological variable being measured.

Contd.

Processor -- Without an accurately known relationship between the input and the output of the processor, the information contained in the sensor output signal would be meaningless after it passed through the processor. For the processor to be accurate it must also be stable, its input-output relationship must remain constant, and it must be reliable so it can be depended upon to carry out its function.

Contd.

Display -- The final block of the generalized instrumentation system is the display and/or storage portion of the system. The function of this block is to present and, in some cases, record data on the variable or variables being measured by the instrument system in such a way that it can be read and analyzed by a human operator or a computer. A *display device presents* instantaneous data so that it can be read from the instrument by a human, but it does not remember any of the data. Thus, a display must be continuously watched if the data is to be carefully observed.

Contd.

There are several types of display devices that are useful in the biomedical instrumentation. These are listed as follows:

1) *Analog scale*
2) *Digital readout*
3) *Loud speaker or other sound source*
4) *Cathode ray tube or flat panel solid state display*
5) *Indicator lamp or Light Emitting Diode*

Examples of display devices

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