Al-Mustaqbal University College
Biomedical Engineering Department

Subject: Biomedical Instrumentation Design.

Class (code): 4th (BME416)

Lecture: 1

Biomedical Instrumentation Design

› According to WHO: ‘Medical device’ means any instrument, apparatus, implement, machine, appliance, implant, reagent for in vitro use, software, material, or other similar or related article, intended by the manufacturer to be used, alone or in combination, for human beings, for one or more of the specific medical purpose(s) of:

- diagnosis, prevention, monitoring, treatment, or alleviation of disease,
- diagnosis, monitoring, treatment, alleviation of, or compensation for an injury,
- investigation, replacement, modification, or support of the anatomy or of a physiological process,
- supporting or sustaining life,
- control of conception,
- disinfection of medical devices,
- providing information by means of in vitro examination of specimens derived from the human body;

Biomedical Instrumentation Design

Generalized Medical Instrumentation System

- The major difference between this system of medical instrumentation and the conventional instrumentation system is that the source of the signals is living tissue or energy applied to living tissue. The design of the instrument must match:
- Measurement needs (environmental conditions, safety, reliability, etc.).
- Instrument performance (speed, power, resolution, range, etc.).

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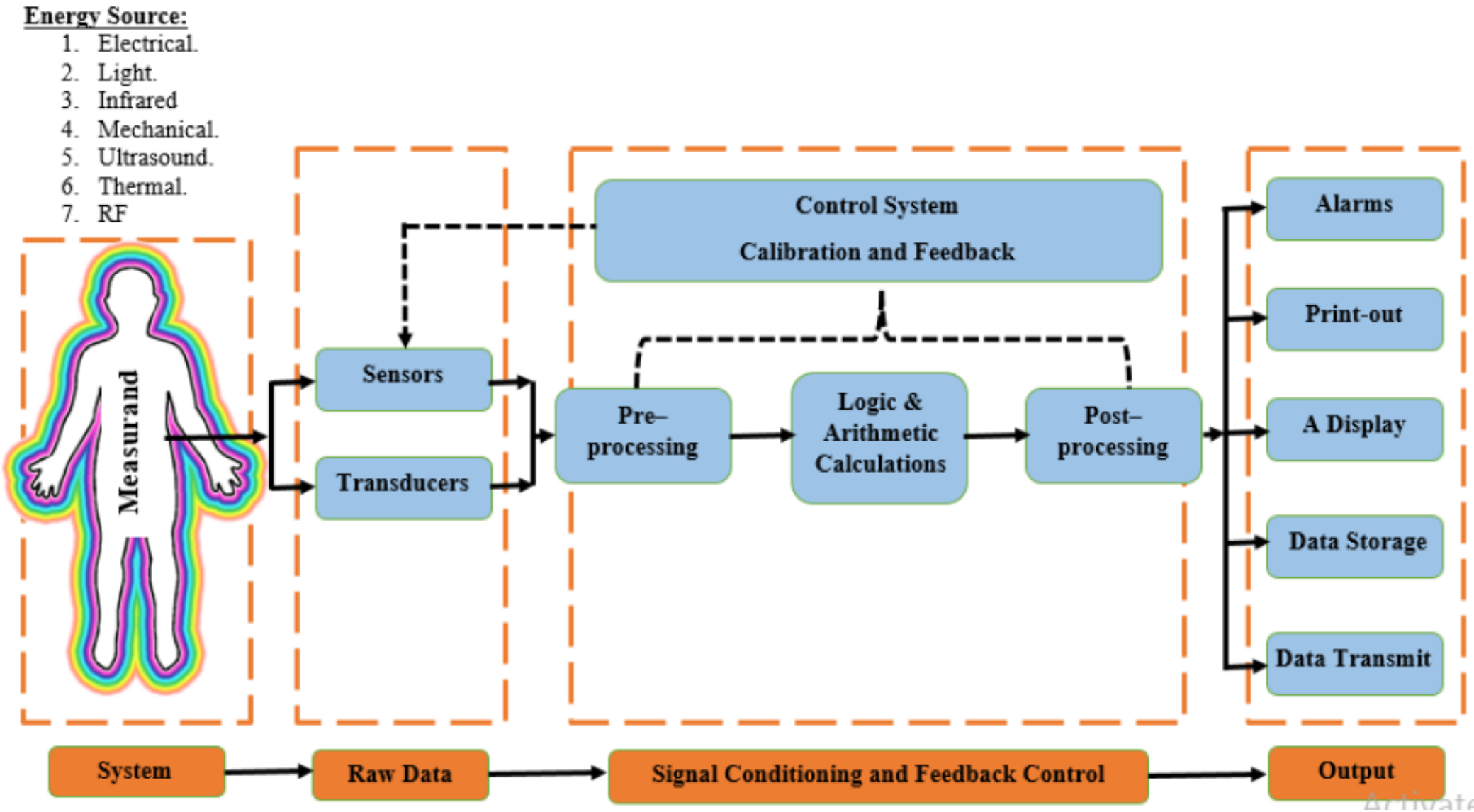

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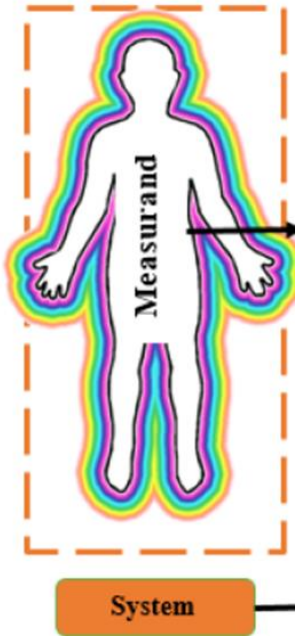
- Measurand: the physical quantity, property, or condition that the system measures. Types of biomedical measurands:
- *Internal* – Blood pressure.
- *Body surface* – ECG or EEG potentials.
- *Peripheral* – Infrared radiation.
- *Offline* – Extract tissue samples, blood analysis, or biopsy.



- Typical biomedical measurements quantities: Biopotential, pressure, flow, dimensions (imaging), displacement (velocity, acceleration, and force), impedance, temperature, and chemical concentration. The measurand may be restricted to an exact organ or anatomical structure.

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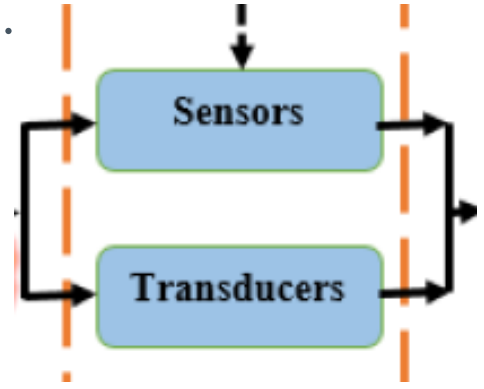
Sensor and transducer

- A sensor is a device that converts physical measurand to an electrical output, in contrast, a transducer is a device that converts one form of energy to another.
- Sensor requirements:
- Selective – should respond to a specific form of energy in the measurand.
- Minimally invasive (invasive = requiring entry into a part of the body).
- Sensor should not affect the response of the living tissue. Most common types of sensors in biomedical systems: are displacement and pressure.



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Many sensors have:

1. A primary sensing element such as diaphragm, converts pressure to displacement.

2. A variable conversion element, such as a strain gage, then converts displacement to an electrical voltage

3. Sometimes the sensitivity of the sensor can be adjusted over a wide range by altering the primary sensing element.

4. Many variable conversion elements need external electric power to obtain a sensor output.

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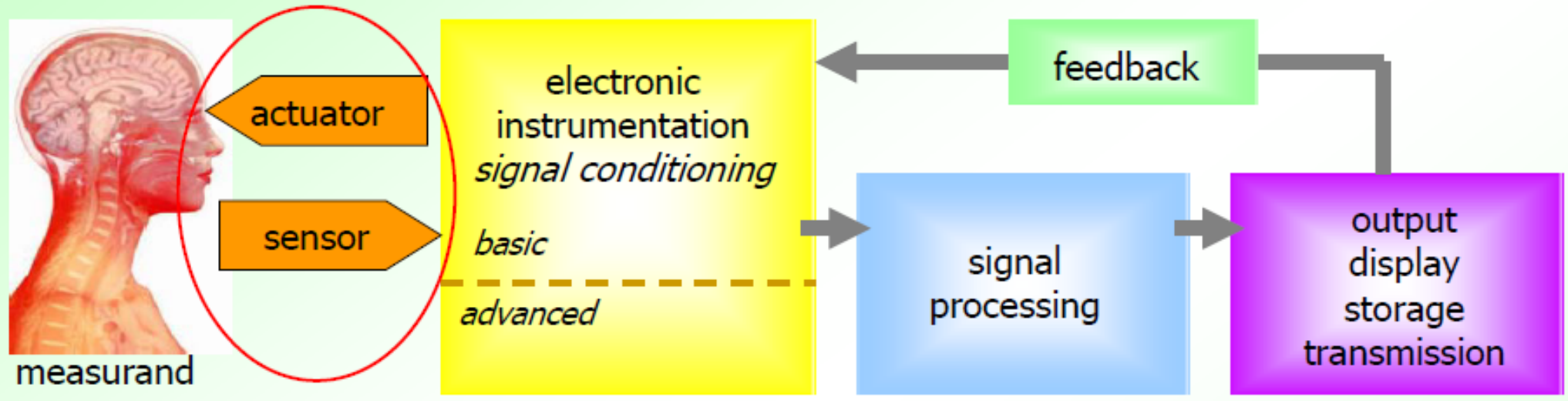

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- ***Signal conditioning***
  - *Signal Conditioning:* Amplification and filtering of the signal acquired from the sensor to make it suitable for display
  - General categories:
    - Analog, digital, or mixed-signal signal conditioning
    - Time/frequency/spatial domain processing (e.g., filtering)
    - Calibration (adjustment of output to match the parameter measured)
    - Compensation (remove undesirable secondary sensitivities)

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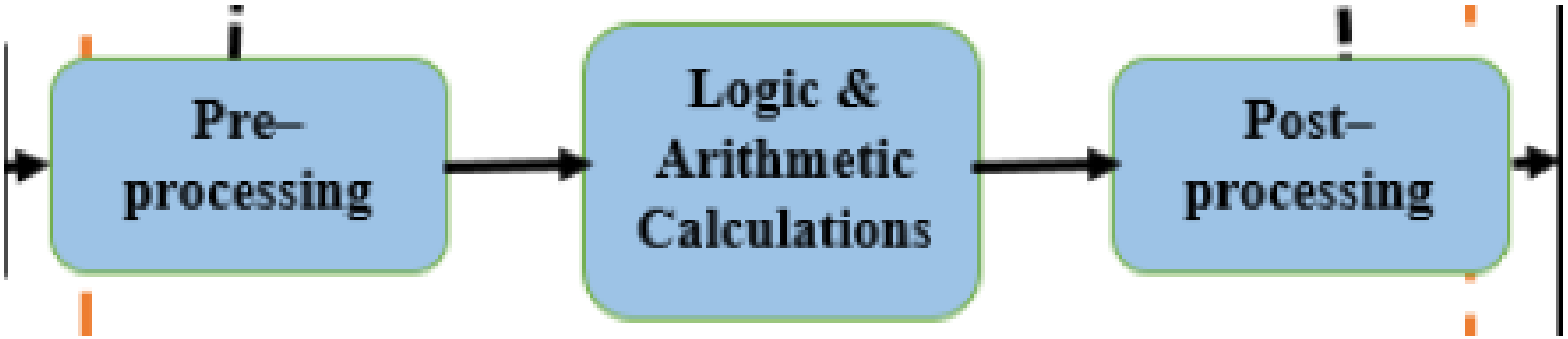
› ***Preprocessing:***

› Usually, the sensor/transducer output had a range of millivolts, so it should be amplified initially (pre-amplification) in order to meet the hardware requirements for further processing.

› The gain of the amplifier on this stage depends strongly on the next stage's requirements.

› Often the output is converted to digital form and then processed by specialized digital circuits or a microcomputer as there will be logic and arithmetic units.



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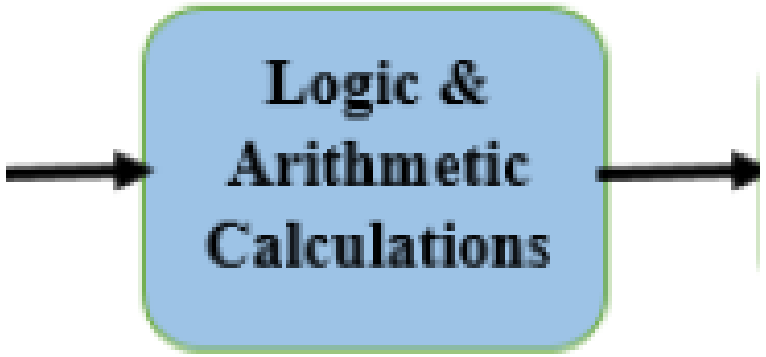
Logic and arithmetic control:

› The basic and complicated modes of calculations for the raw amplified data gathered from the patient's body through the sensor/transducer are performed.

› signal filtering adjustment, based on operator selection mode, mathematical manipulation between inputs to calculate required parameter and so on.



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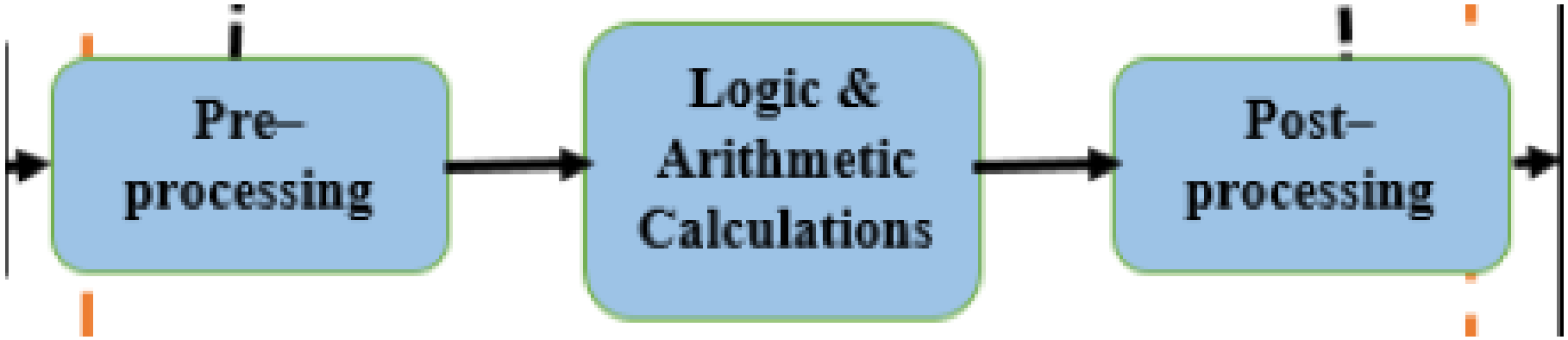
- ***Postprocessing:***

- Final processing is performed. Either based on manipulating the signal to match the requirement of the output elements or to adjust the scale of: time, frequency, and signal level for the real shape mode. Specialized digital circuits or a microcomputer are used to perform several functions like: average repetitive signal, reduce noise, and converting information from the time domain to the frequency domain.



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