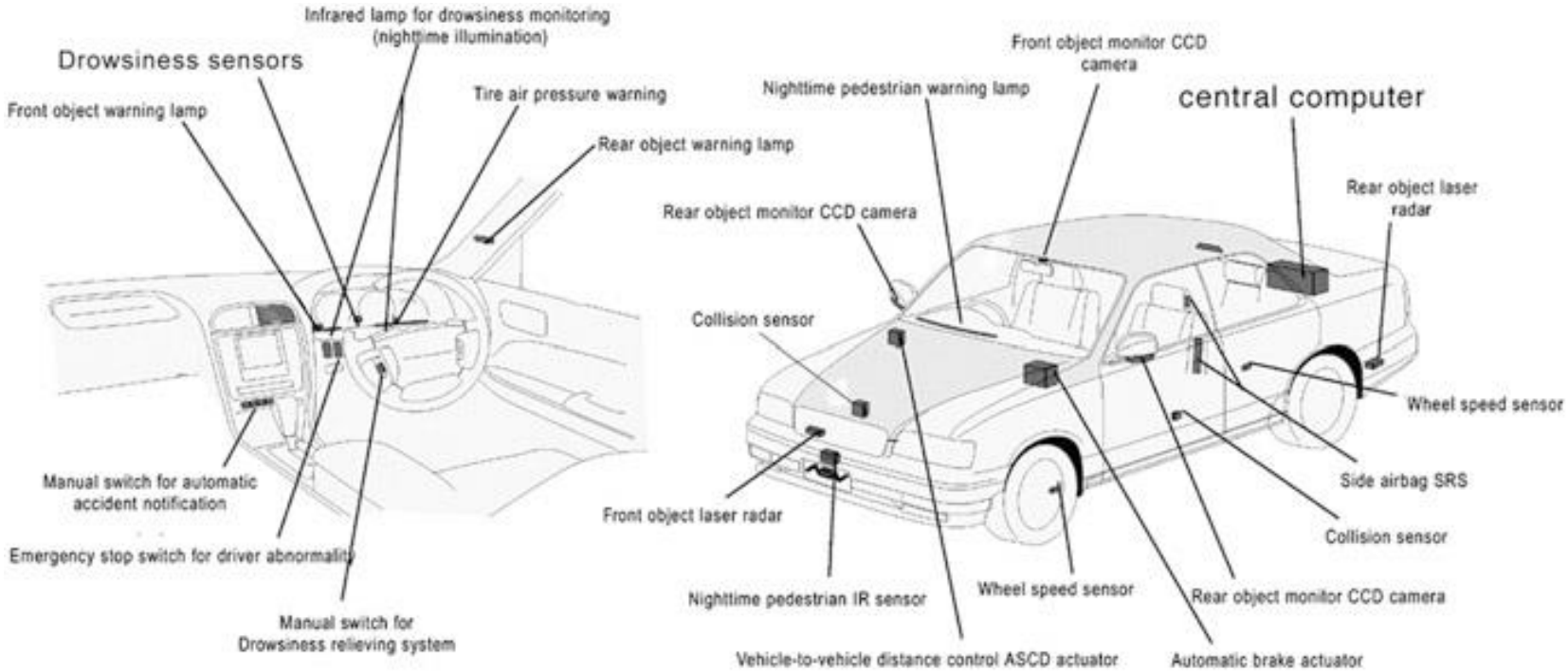
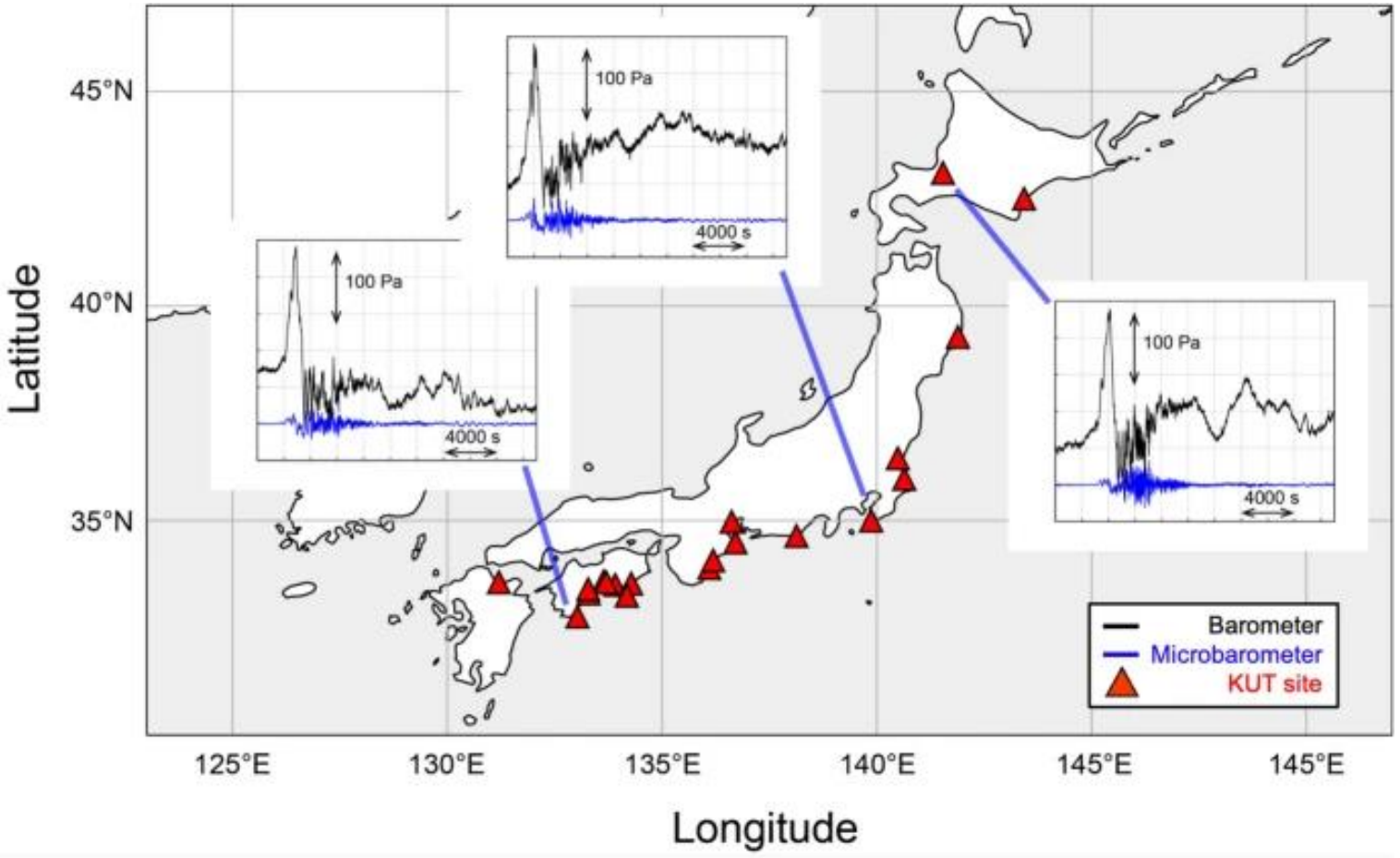
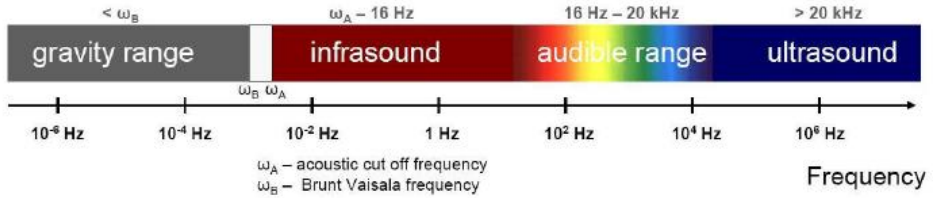
Classification



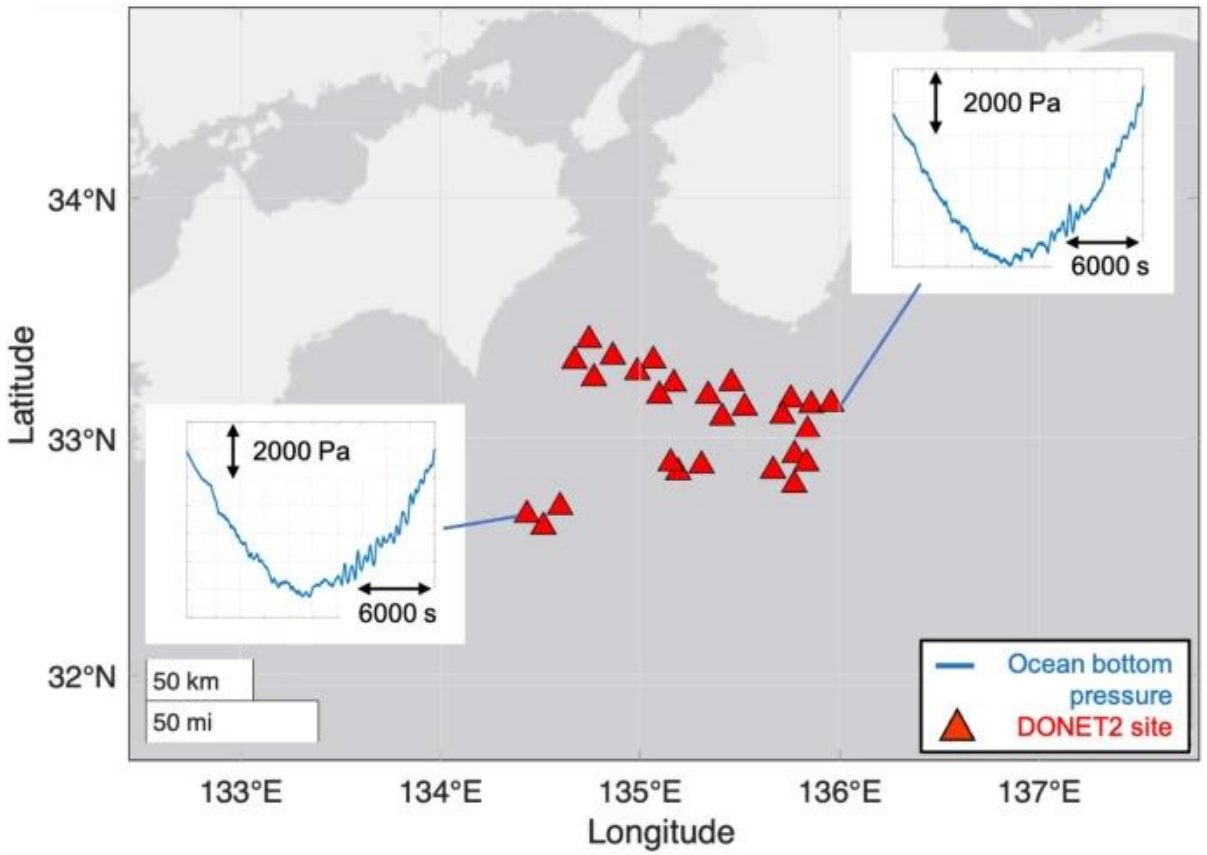
Multiple sensors, actuators, and warning signals are parts of the Advanced Safety
Vehicle (Courtesy of Nissan Motor Company) (from the book by Jacob Farden (2016)





Location of Kochi University of Technology (KUT) infrasound sensors and their observed data after the Tonga volcanic eruption. The KUT installed more than 30 infrasound sensors to form a Japan-wide infrasound observation network. Every site has a SAYA INF01-type comprehensive sensor that contains a membrane-type infrasound sensor, a barometer, a thermometer, and a three-component accelerometer of small MEMS sensor chips. These observation sites are 7700 to 8400 km away from Tonga volcano, and the pressure fluctuations were monitored approximately 7 hours after the eruption. Examples of time series of pressure perturbation are shown; the observed signals had similar waveforms regardless of their locations.

Nishikawa et al., 2022



Location of DONET2 (Dense Oceanfloor Network system for Earthquakes and Tsunamis) sites. These 27 ocean bottom pressure gauges are installed for the early detection of tsunamis by observing the vertical movement of the sea surface through the observation of changes in water pressure.

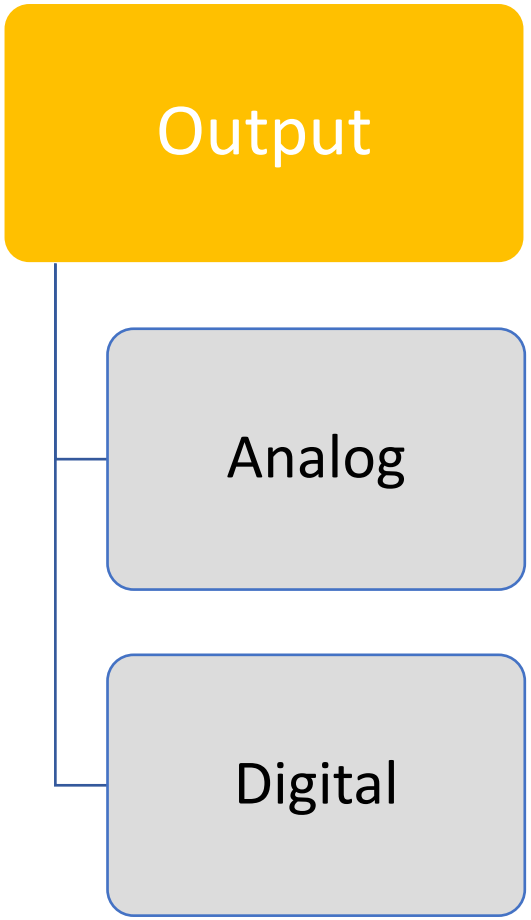
Sensor & transducer

- Sensor: an input transducer (i.e., a microphone)
- Actuator: an output transducer (i.e., a loudspeaker)

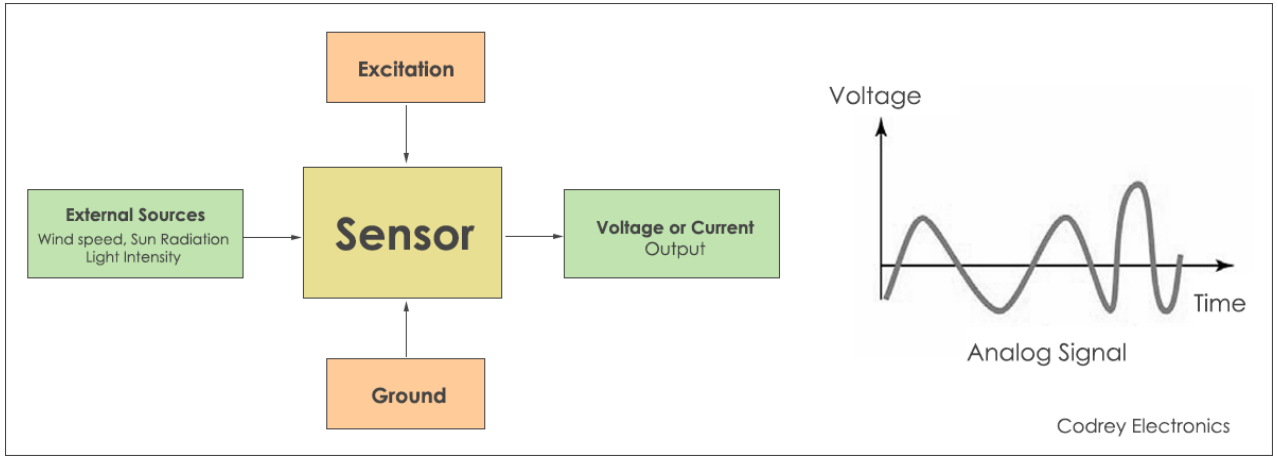
- loudspeaker, which converts an electrical signal into a variable magnetic field (acoustic waves).
- A loudspeaker, when connected to an input of an amplifier, may function as a microphone. In that case, it becomes an acoustical sensor.

- https://www.youtube.com/watch?v=9XTqD44Q9WA

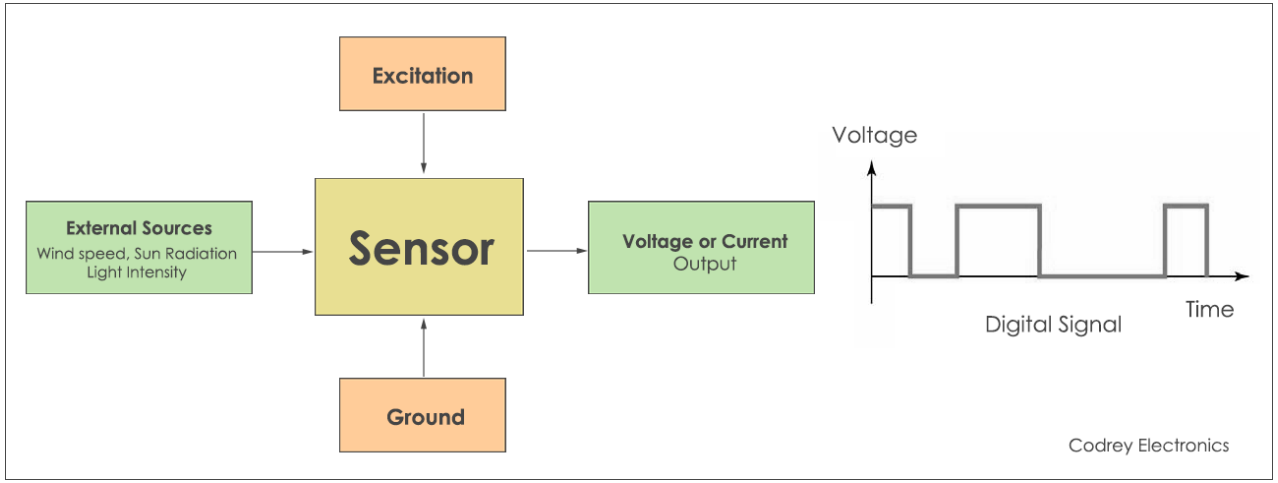
Types of Sensors



Sensor Classes (Based on Output)

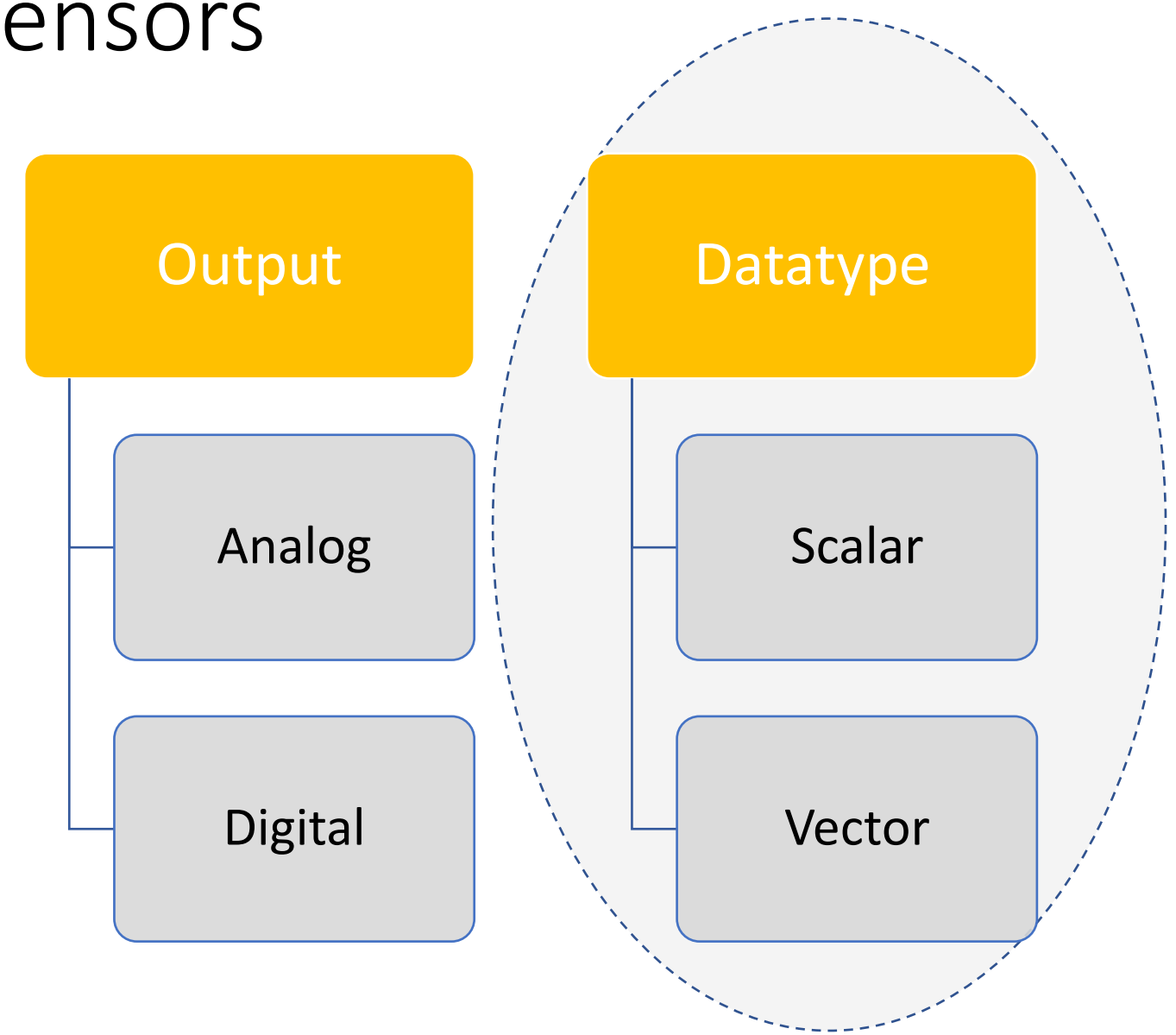


Analog Sensor



Digital Sensor

Types of Sensors



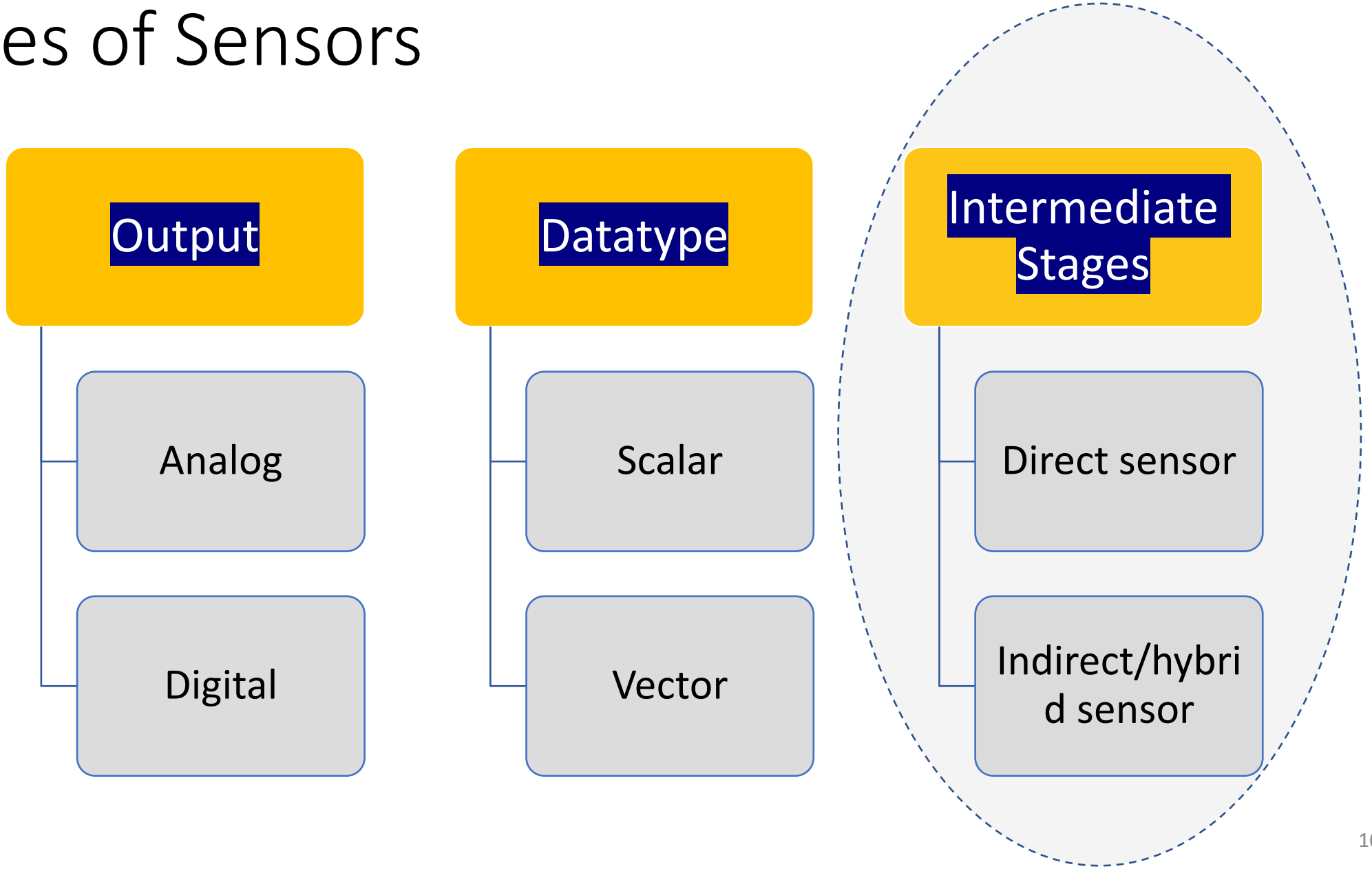
Sensor Classes (Based on Data Type)

- Scalar Sensor: Produces output voltage which is proportional to the magnitude of the quantity measured
  Physical quantities: temperature, color, pressure, etc

- Vector Sensor: Produces output voltage which is proportional to the magnitude, direction and the orientation of the quantity measured (Camera sensor)

  Physical quantities: Sound, image, velocity, acceleration

Types of Sensors



Types of Sensors

- Direct Sensor:
  Converts a stimulus into an electrical signal or modifies an electrical signal by using an appropriate physical effect

or

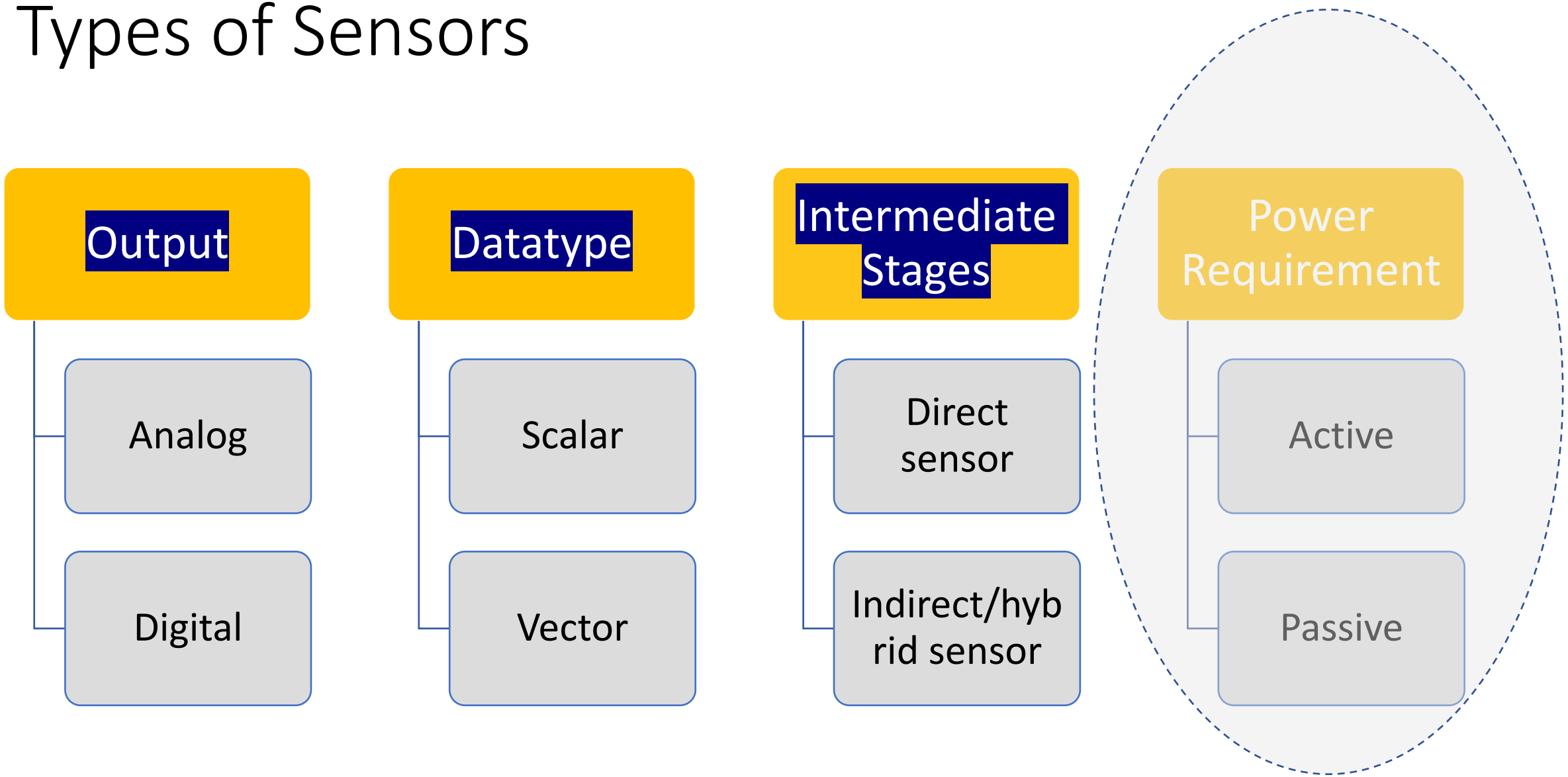
- The direct sensors are those that employ certain physical effects to make a direct energy conversion into a generation or modulation of an electrical signal
  Example: Thermocouple

What is photoelectric effect?

- Indirect/hybrid Sensor:
  Includes one or more transducers for multiple conversion steps before a direct sensor generates an electrical output.

Example: rotary encoder

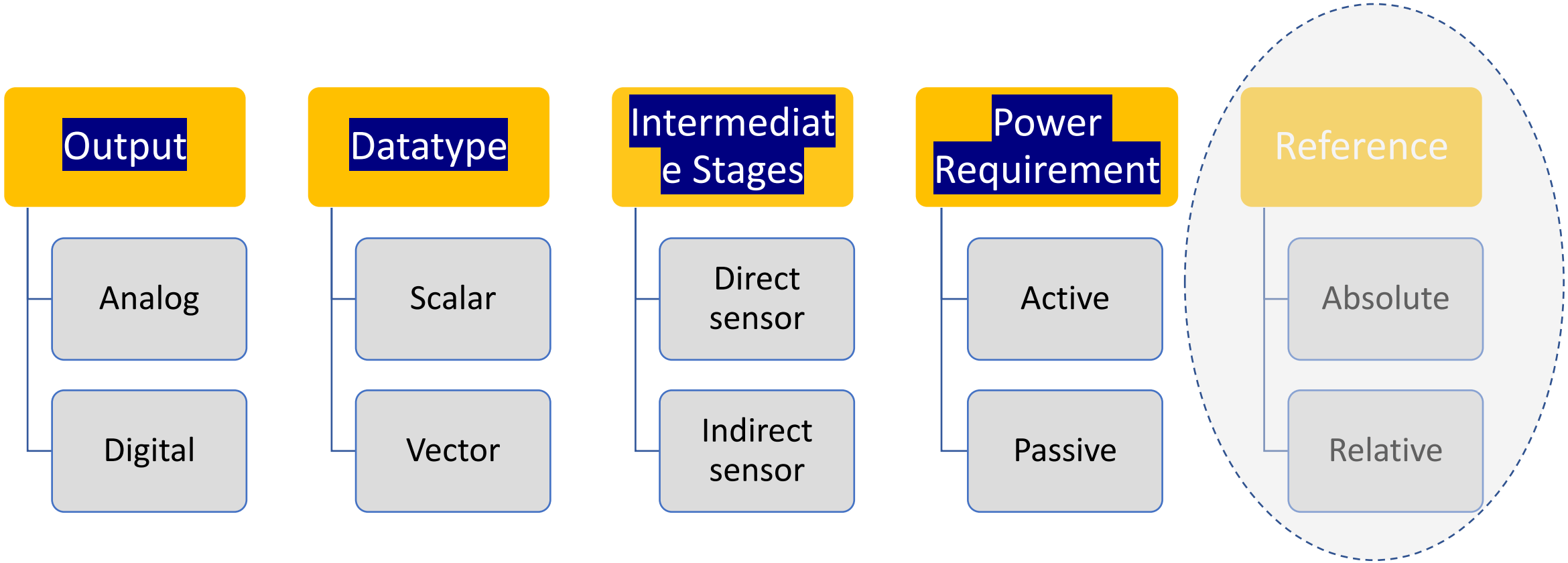
Types of Sensors



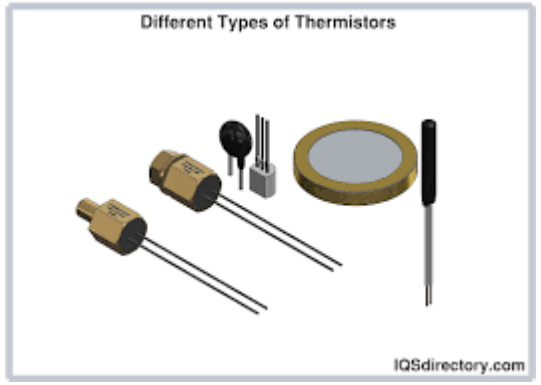
Types of Sensors

- Passive Sensor:
  Does not need any additional energy source and directly generates an electrical signal in response to external stimulus.
  Most passive sensors are direct sensors as defined earlier.
  Example: Thermocouple, photodiode, piezoelectric sensor
- Active Sensor:
  Requires external power for its operation, which is called an excitation signal.
  Example: LiDAR, GPS, infrared sensor

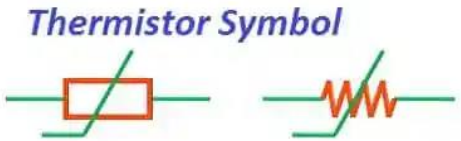
Types of Sensors



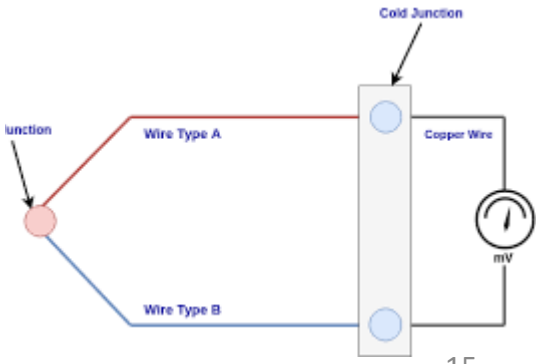
Types of Sensors



- Absolute Sensor:
  Detects a stimulus in reference to an absolute physical scale that is independent of the measurement conditions
  Example: Thermistor

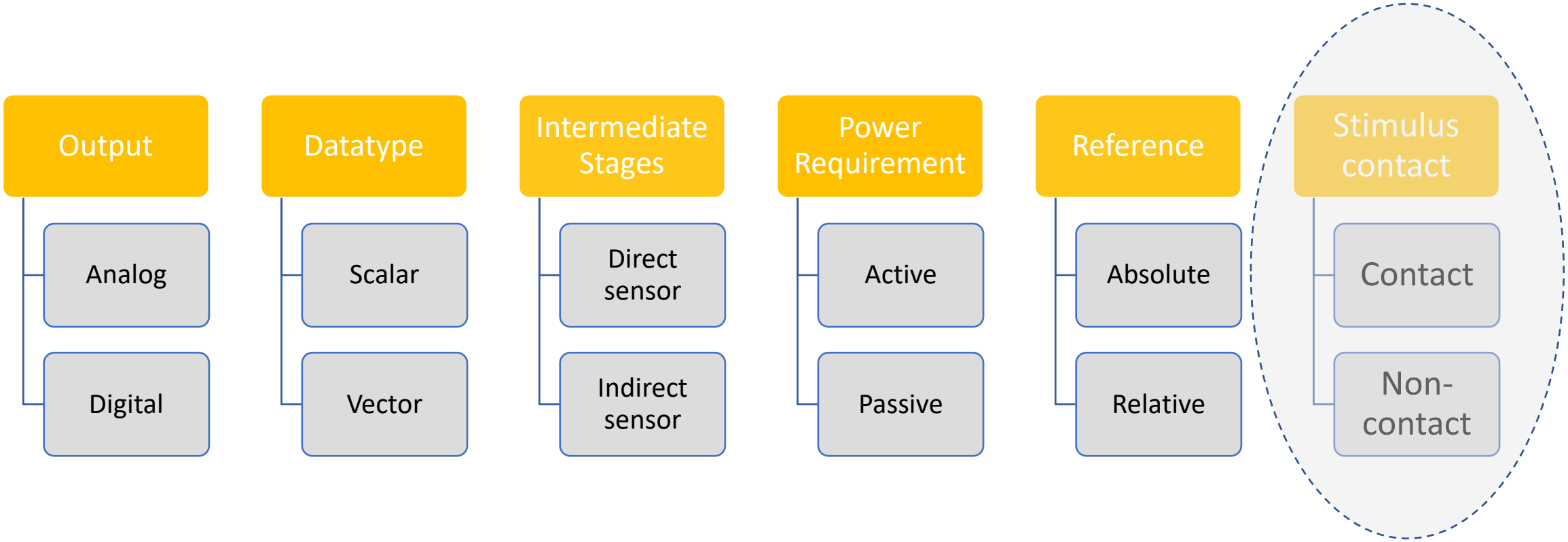


- Relative Sensor:
  Stimulus is sensed with respect to a fixed or variable reference that is not an absolute value independent of measurement conditions
  Example: Thermocouple



Lookup: Seebeck effect

Types of Sensors



Types of Sensors

- Contact sensor:
  Requires physical contact with the stimulus
  Example: strain gauges, temperature sensors

- Non-contact sensor:
  Requires no physical contact
  Example: optical and magnetic sensors