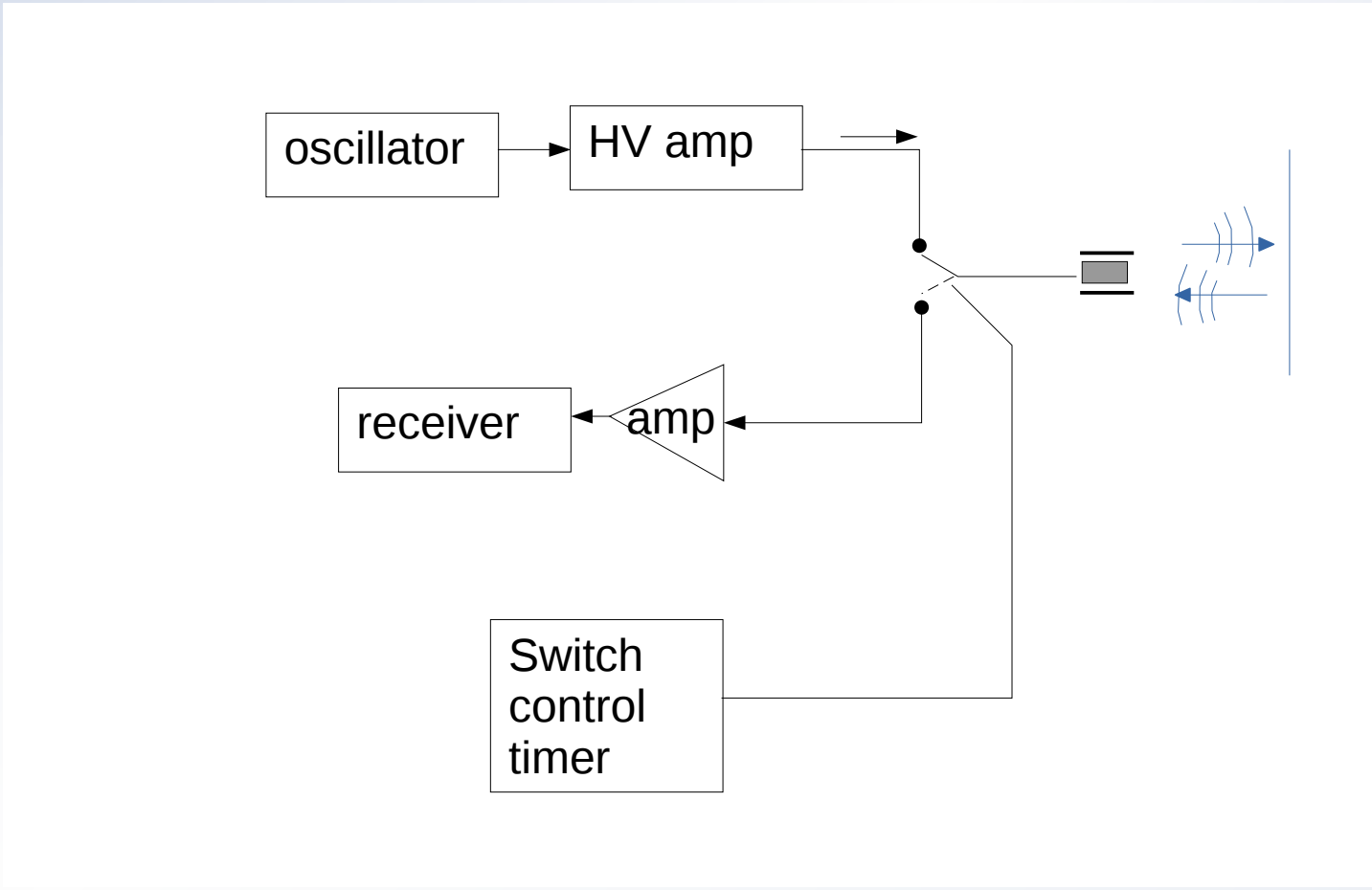
Review

Suresh Devasahayam
Department of Bioengineering
Christian Medical College, Vellore

Ultrasound Measurement

Ultrasound Reflection Measurement



Ultrasound Instruments

- Time of echo:

$$\tau = 2\frac{d}{c}$$

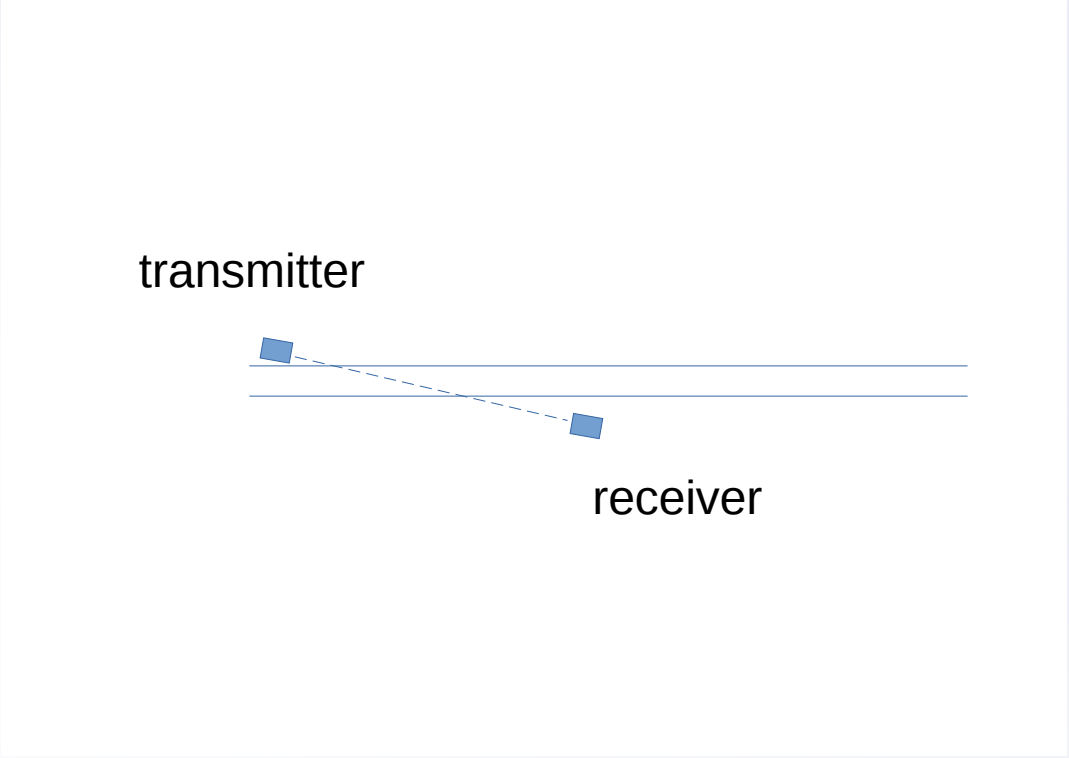
- Attenuation:

$$\frac{I_r}{I_o} = e^{-\mu(2d)}$$

- Automatic depth dependent gain compensation

Flow measurement

- Transit time =
  distance / (effective velocity in medium)



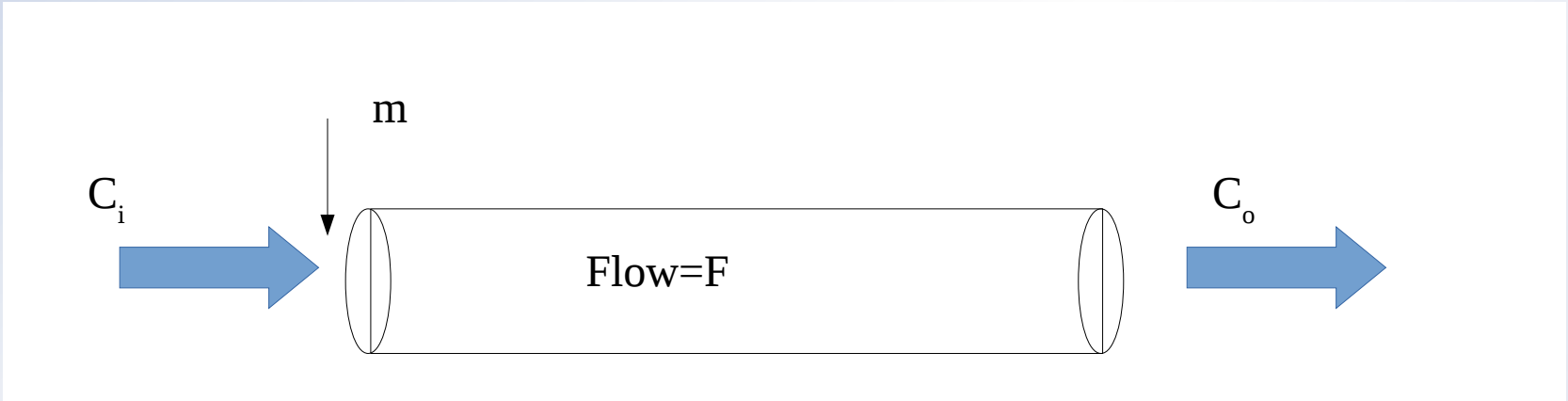
Doppler shift

- Source frequency f_o
- Source-target velocity u
- Propagation in medium with velocity c
- Dopplet shift f_d

$$\frac{f_d}{f_o} = \frac{u}{c}$$

Flow Measurement

Dilution methods

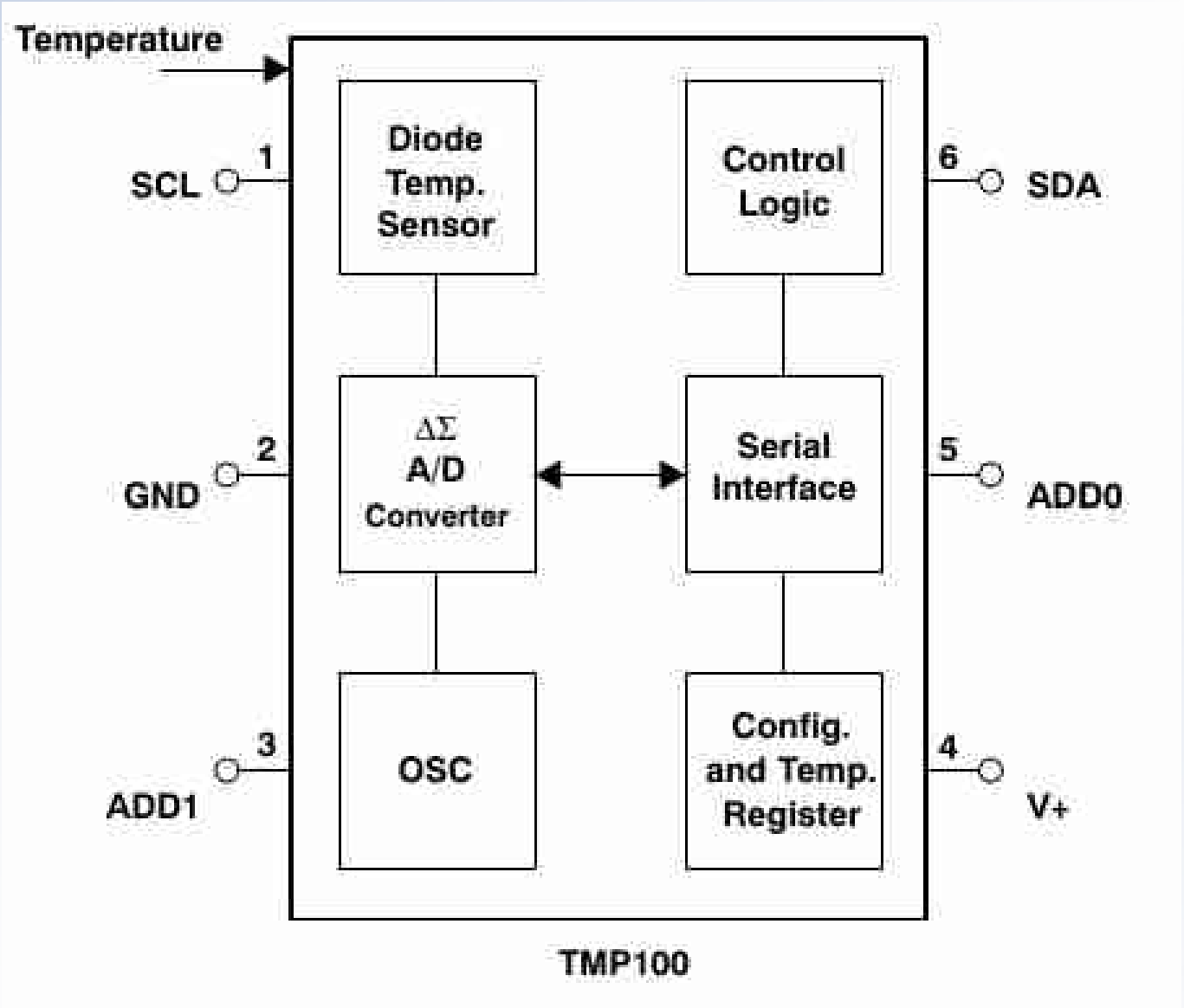


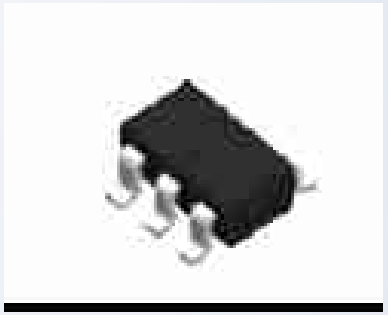
$$C_i F + \frac{dm}{dt} = C_o F$$

$$F = \frac{dm/dt}{C_o - C_i}$$

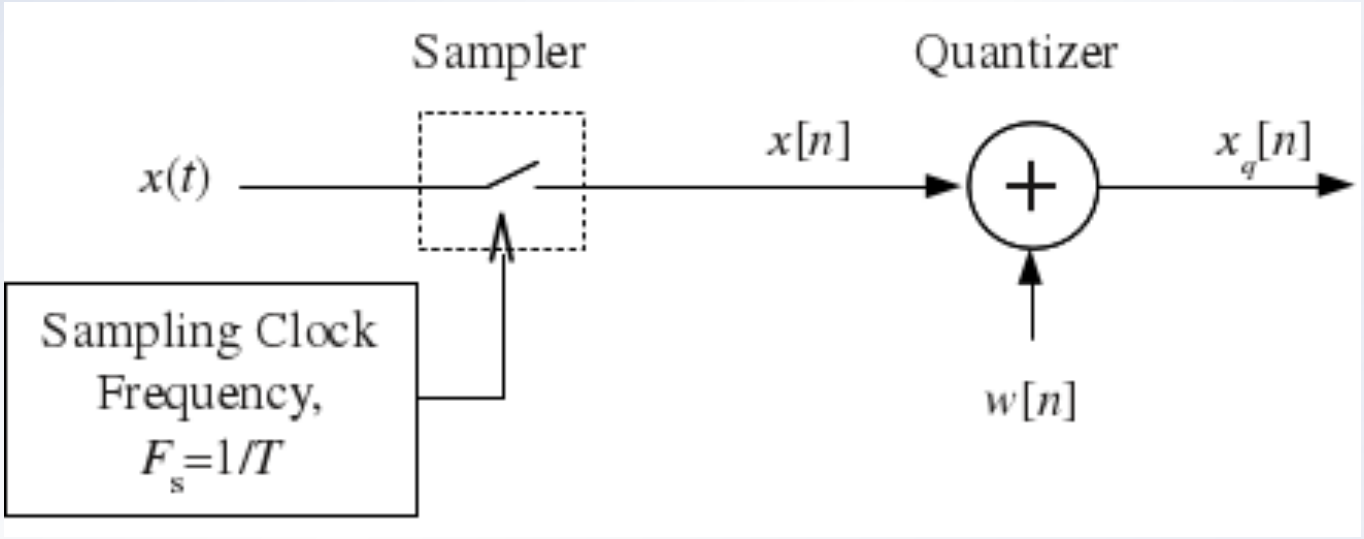
Digital Measurement

Digital Temperature sensor - TMP100



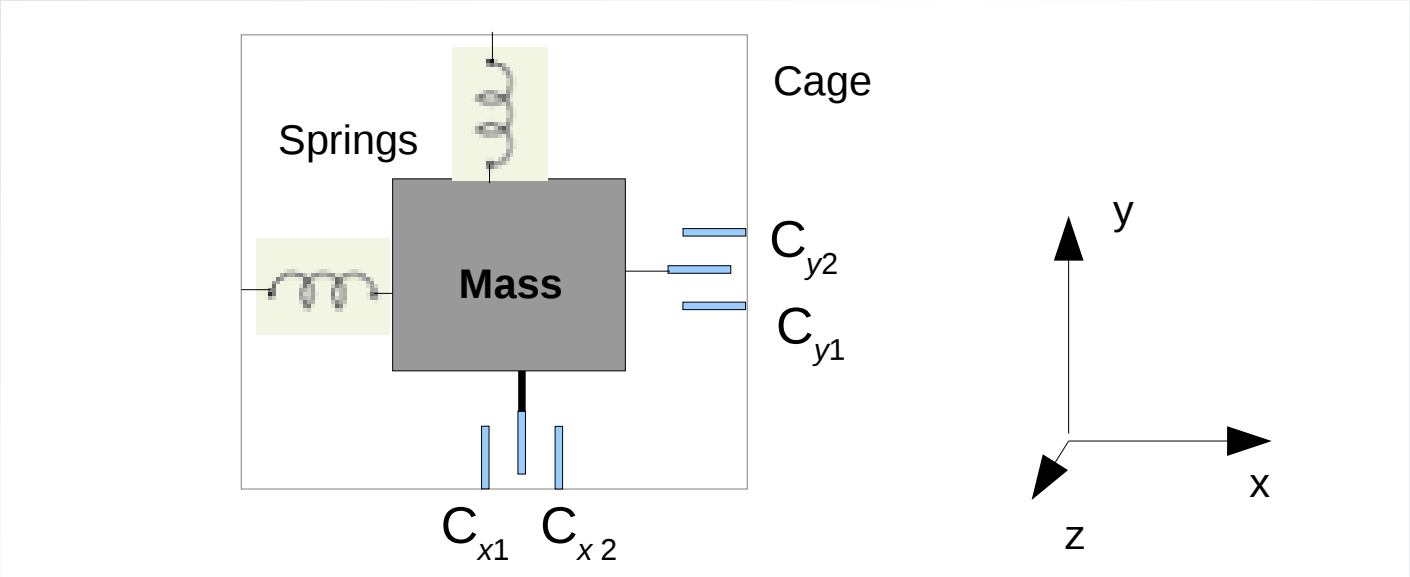


Digitization and Quantization

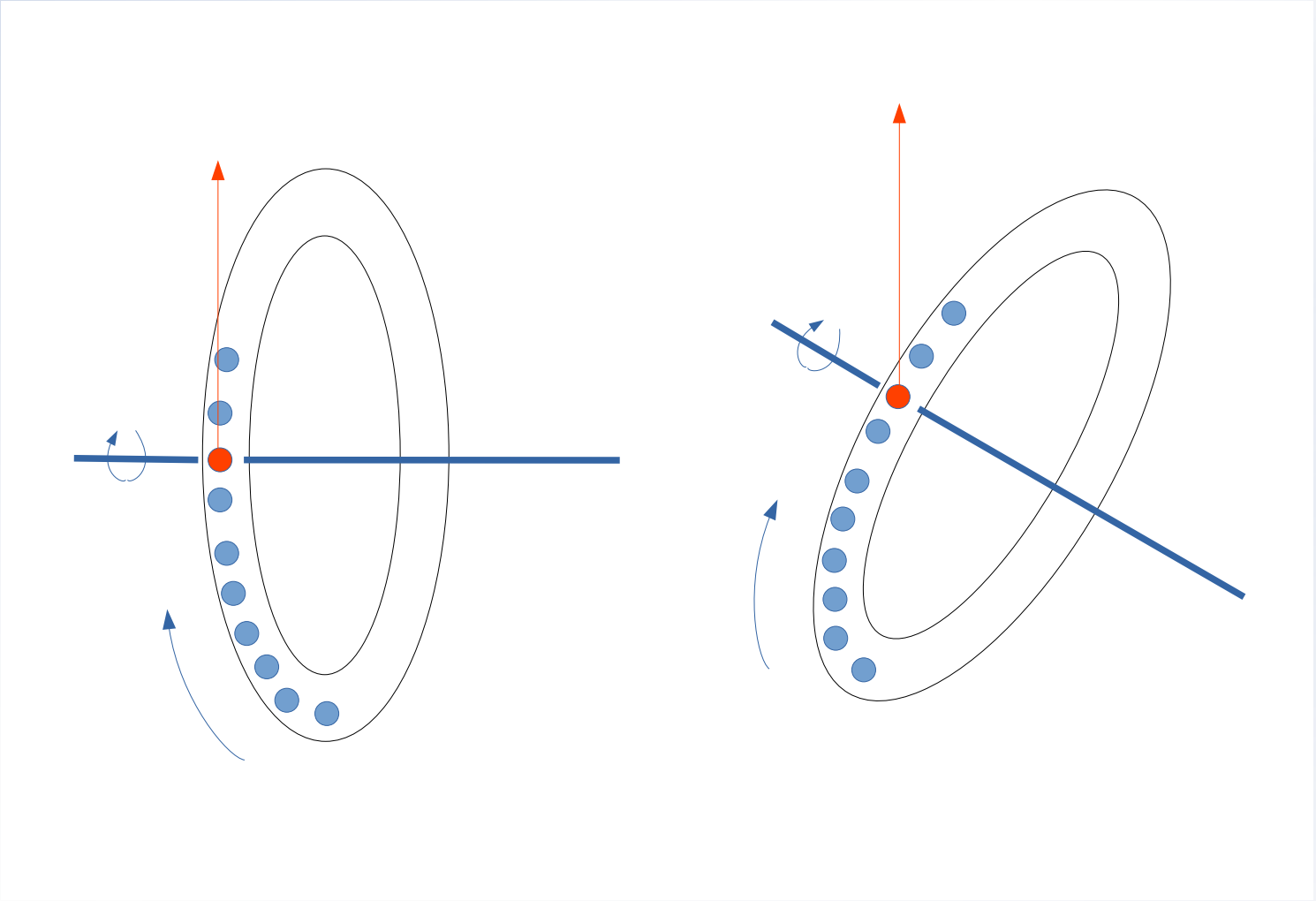


Inertial Sensors

Measurement of Acceleration



Gyroscope Principle



Disc gyroscope

$$mgr = \omega_s \omega_p I_s$$

- Mass, m
- Radius of disc, r
- Spin angular vel
- Precession angular vel
- Spin moment of inertia

Vibrating gyroscope – Coriolis force

- Force, F
- Angular Velocity of rotation/precession
- Linear velocity of oscillation
- Mass, m

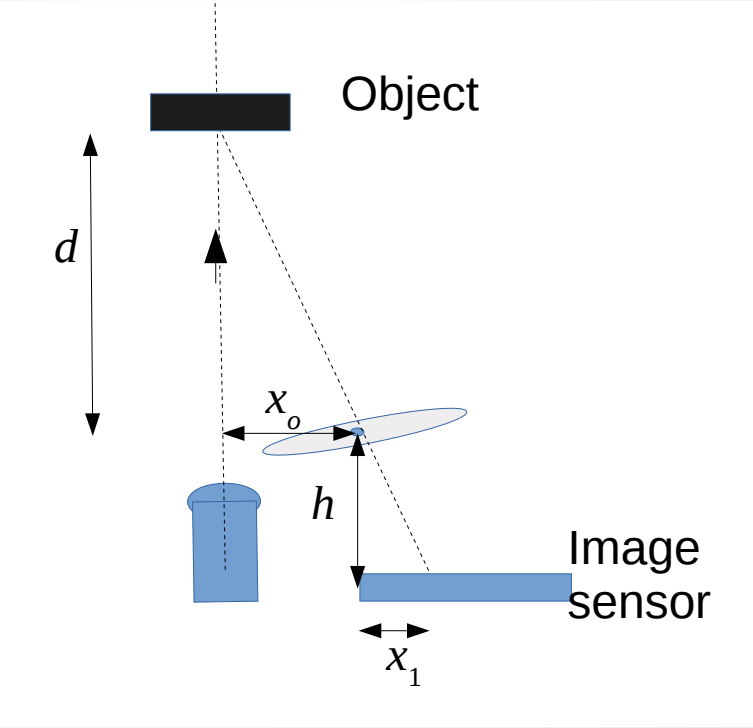
$$F = -2\,\omega_p\,v_{osc}\,m$$

Distance Measurement

Triangulation calculation

$$\frac{d}{h} = \frac{x_o}{x_1}$$

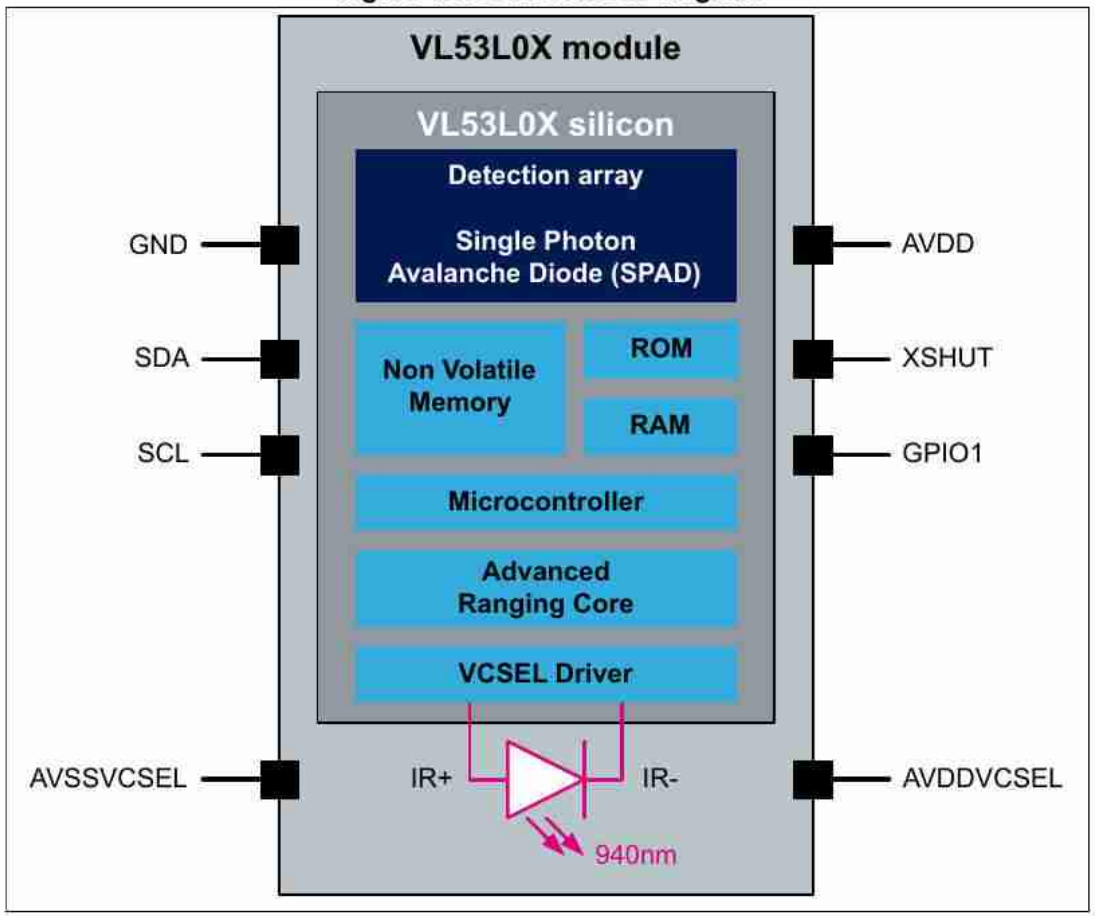
$$d = x_o h \cdot \frac{1}{x_1}$$



ToF LiDAR

System block diagram

Figure 1. VL53L0X block diagram



Radiation Thermometry

Stefan-Boltzman Law – radiation (absorbed/emitted)

- Integrating Wien's equation can get total thermal power
  - integrate numerically
- Empirical formula by Stefan and Boltzman
- For black body, the emissivity is 1
- 'A' is a geometry factor

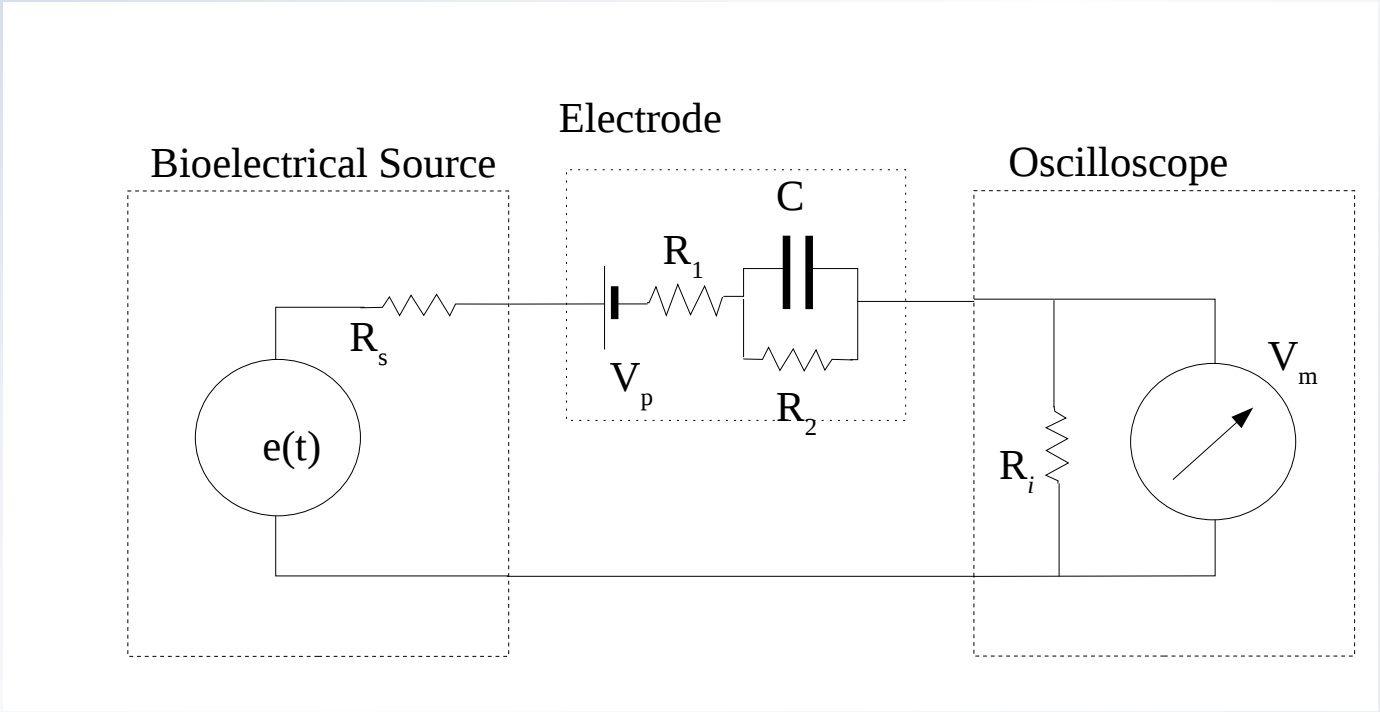
$$P_{tot} = A\,\epsilon\,\sigma T^4$$

$$P_{tot(blackbody)} = \sigma T^4$$

$$\sigma = 5.67037\,Wm^{-2}K^{-4}$$

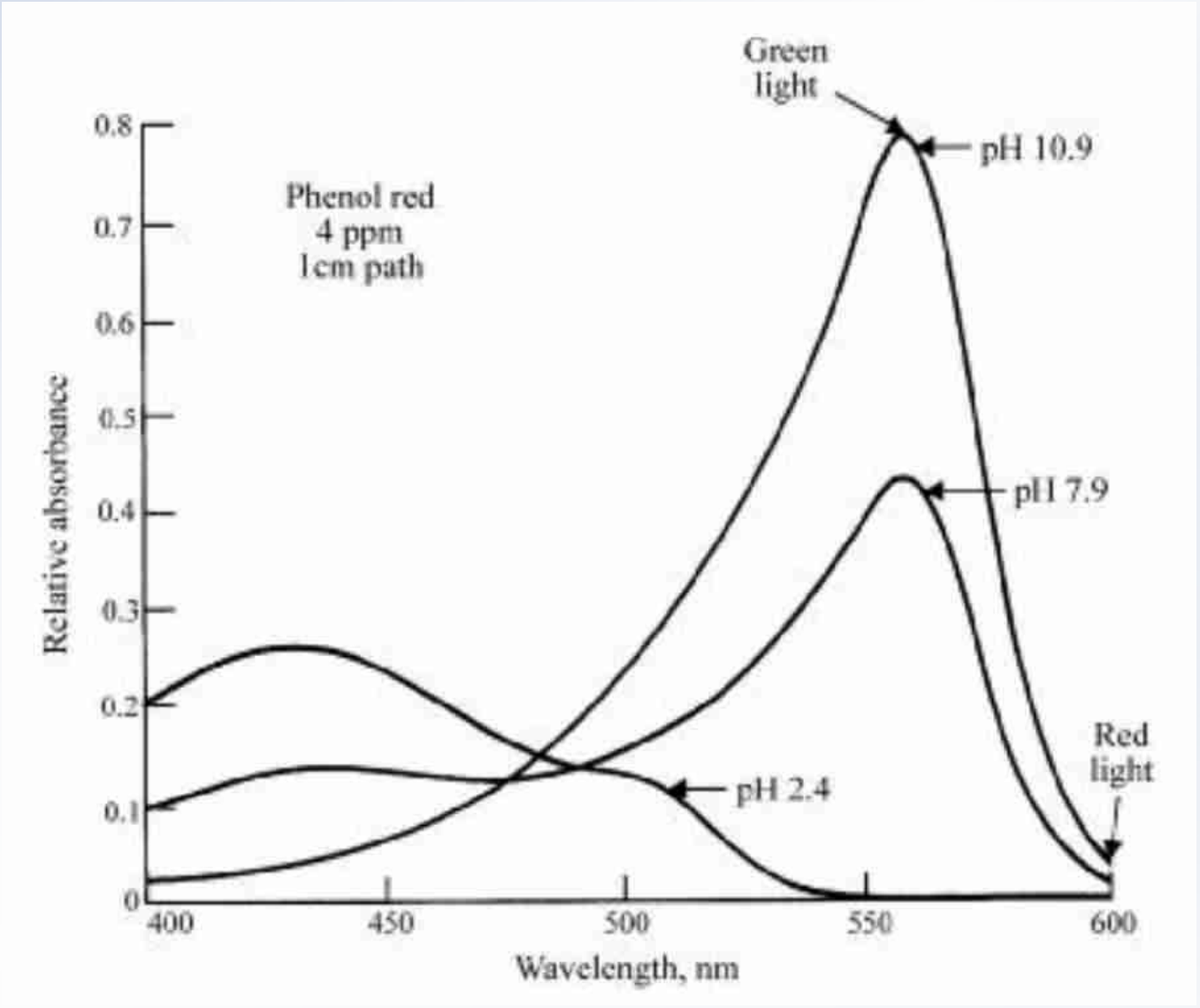
Biopotential Electrodes

Measurement model



Photospectrometry

Absorption spectrum change of phenol red with pH



Examples requiring Design

1. Measuring eye-blink for noise removal

- Noise in EEG recording
- Remove noise by subtracting blink event-related potential
- Determine transfer relation between blink measurement and EEG measurement

2. Measuring eye-blink to use as control signal

- Locked-in patients – eye-blink under voluntary control
- Encode intention as sequence of eye-blinks

3. Electrogastrography

- Measure peristalsis
- Distinguish signal from movement noise

4. Measuring Blood flow in tissue

- Photoplethysmography
- Impedance plethysmography

5. Separating signal from noise

- Similar characteristics
  - ECG/EMG
  - EEG/EMG
- Different characteristics
  - ECG/respiration
  -

Designing Measurement Systems

- Sensitivity
- Selectivity
  - Noise immunity
- Linearity
- Dynamic response
- Non-invasive

- Portability
  - Battery operation
  - Wireless data transfer