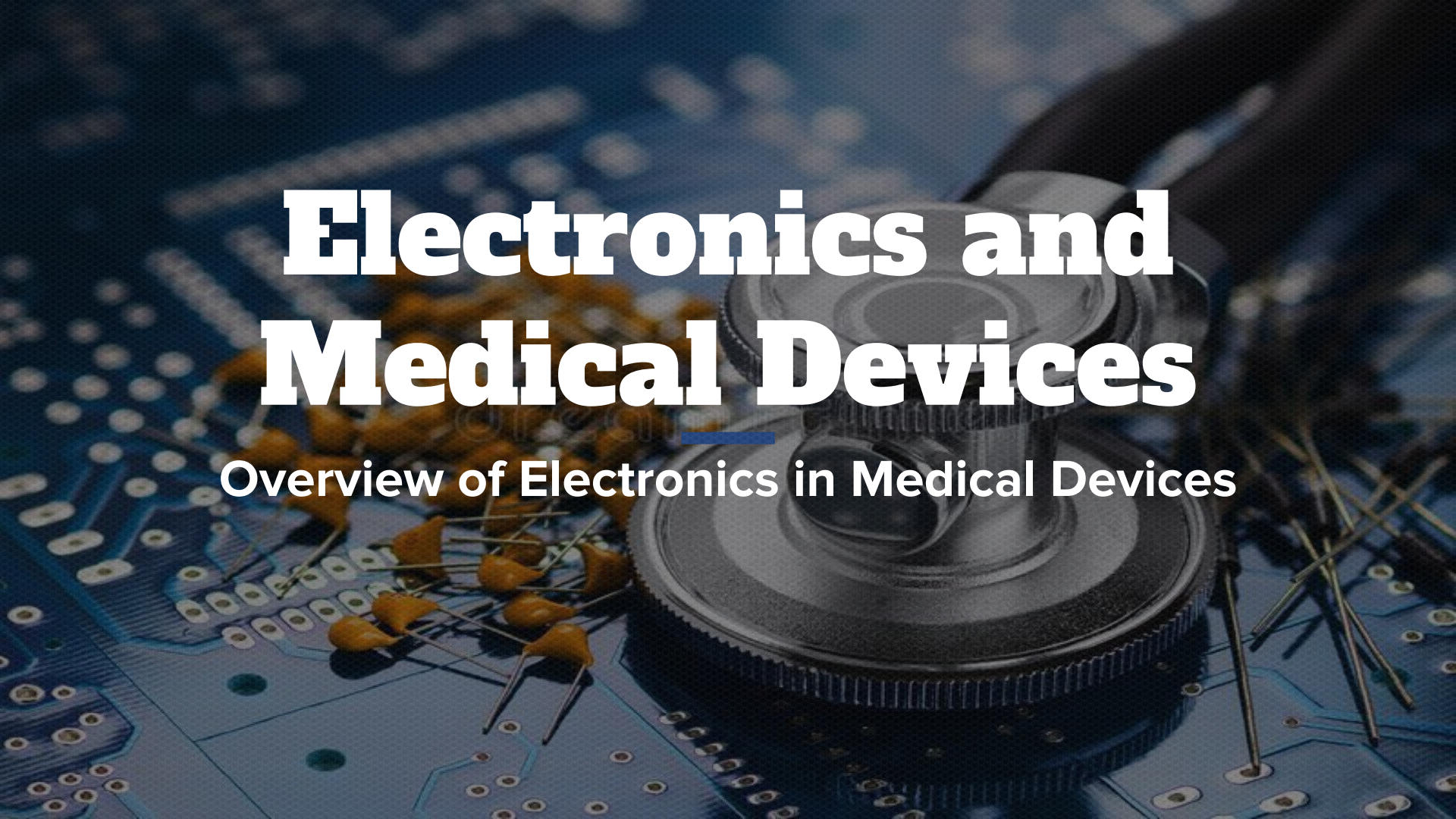

Electronics and Medical Devices

Overview of Electronics in Medical Devices

Team Members :

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Biomedical Equipment

•Biomedical Equipment technology is a profession that requires broad knowledge of biomedical system instrumentation.

•Necessary knowledge includes system usage, maintenance responsibilities, and ways to obtain data on an extensive range of monitoring, diagnostic, therapeutic, and surgical instrumentation.

•A biomedical equipment technologist must study electronics, electronics management, medical physiology, and computer applications.

Use of biomedical equipments:

- Biomedical Equipment are now used for quick diagnosis, flawless surgery and therapeutics.
- Use of a malfunctioning BME could result in faulty diagnosis and wrong treatment.
- BMEs are used with machines to diagnose and treat diseases.

Types of biomedical equipment:

Biomedical Equipments can be of following types:

- Diagnostic Equipment
- Durable Medical Equipment(DME)
- Treatment Equipment
- Life Support Equipment
- Medical Laboratory Equipment

Diagnostic Equipment:

- Used for diagnosing a patient's condition.
- Performed based on patient's symptoms as described by them.
- Specific equipment are used as per the organs or place to be treated internally.
- The doctors look for abnormality in affected organs or parts of the body that are causing the symptoms to be exhibited.

Types of Diagnostic Equipment:

- Medical Imaging Machines
  - -Radiography (x-ray machines)
  - -Computed tomography(CT Scan)
  - -Magnetic Resonance imaging (MRI scan
  - -Ultrasound
  - -echocardiography
- Stethoscopes
- Dopplers
- Pulse oximeters

Durable Medical Equipment(DME):

- Mainly used for providing therapeutic benefits for certain conditions or illness.
- It is a long-term and reusable device that can be used in hospital or at home.
- It is durable because they have been tested for quality, safety and comfort of patients.
- Has non-slip features and load-bearing strength.

Types of DME:

- Wheelchairs
- Hospital beds
- Walkers, crutches
- Pressure mattress
- Insulin and breast pumps
- Nebulizers
- Kidney machines
- Oxygen tanks
- Oxygen Concentrators and Ventilators

Treatment Equipment:

- Uses modern technology to address any abnormalities to restore function in affected organs or tissues within the body.
- It can include surgical supplies like:
  - -Diagnostic scopes
  - -Surgical caps, gowns, gloves, glasses (for surgical team)
  - -Gauze and Drapes (for patients)

Types of Treatment Equipment:

- **Infusion pumps** : It infuses medication and fluids into the patient's circulatory system.
- **LASIK Surgical Machines** : Used in the treatment of eye conditions having myopia, hyperopia, and astigmatism.
- **Medical Lasers** : Emits wavelength of electromagnetic radiation for clinical purposes. The wavelengths may vary during energy level and pulse duration.

Life Support Equipment:

- Required to maintain bodily function of a patient.
- Used mainly when patient's organ systems cannot function on their own.

Types of Life support Equipment:

- **Heart-lung Machines (Cardiopulmonary bypass (CB)):** It temporarily functions as heart or lungs of a patient during surgery. Also known as a form of extracorporeal circulation.
- **Medical Ventilators**: Designed as artificial lungs when the patients have difficulty in breathing or are incapable of delivering an adequate supply of oxygen throughout the body.
- **Dialysis Machine:** Used for removing excess solutes or toxins from the blood. Used by people with damaged kidneys. It is a type of renal replacement therapy.
- **Incubators**

Medical Laboratory Equipment:

- Used mainly in medical clinics, hospitals or diagnostic laboratories.
- Intended mainly for analysis of blood, urines, genes, and other biological material.

Types of Medical Laboratory Equipment:

- Blood gas analyzers
- Chemistry analyzers
- Blood collection supplies
- Electrolyte analyzers
- Differential counters
- Drug testing analyzers
- Coagulation analyzers
- Hematology analyzers
- Urinalysis analyzers
- Microbiological systems

Electronic Stethoscope

History & Limitation of Conventional acoustic stethoscope

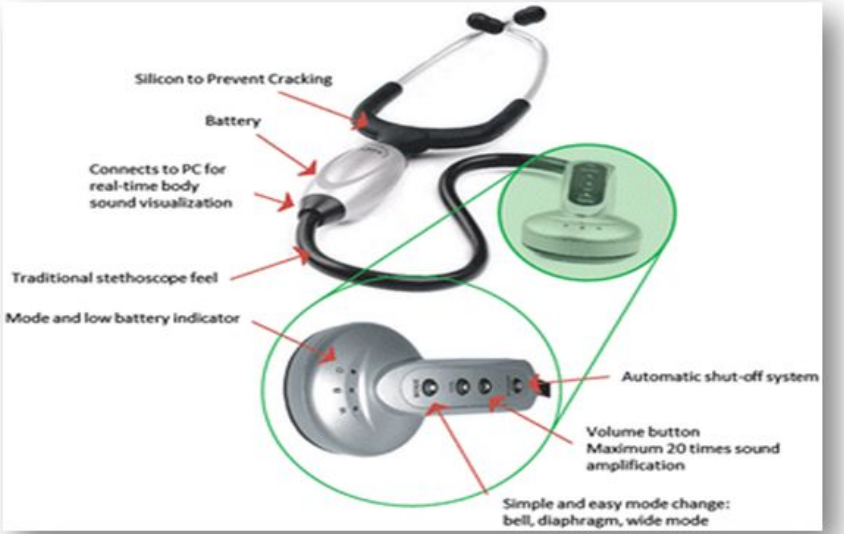
- Heart disease is the leading cause of death in most countries in the world

- Available technology for detection :
  - electrocardiogram (ECG)
  - Echocardiogram (echo)
  - magnetic resonance imaging (MRI)
  - A computed tomography (CT)

- Limitation of Conventional stethoscope:
  - HS data recorded often corrupted with noise à low accuracy
  - interpretation of the HS is very subjective àexperience, skills, and hearing ability of the physician

Electronic Sethoscope

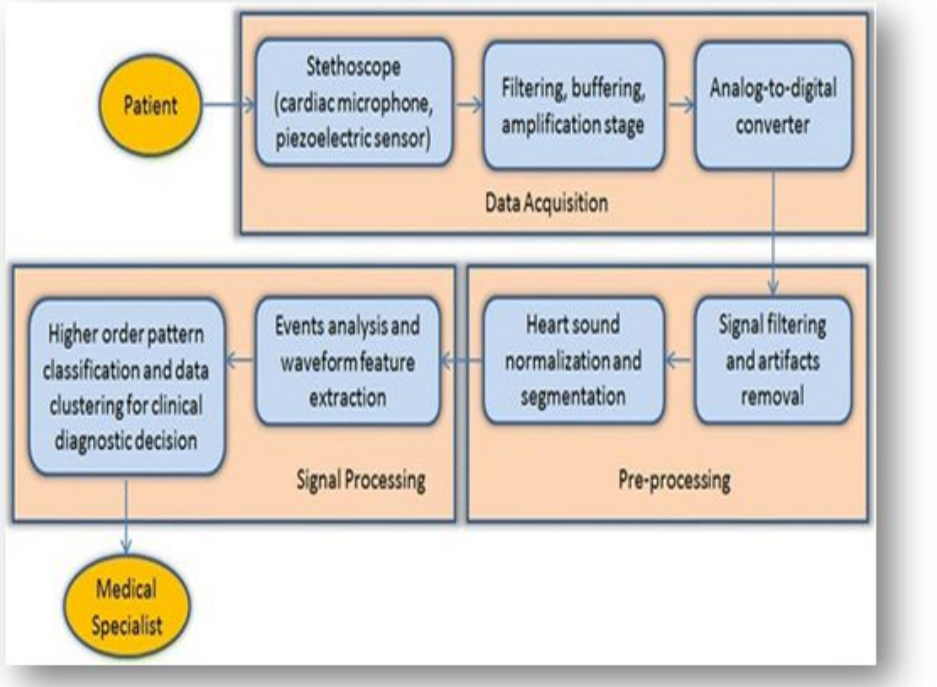
- The two most common ones used are the Littmann 3M model and the Thinklabs One.
- Electronic stethoscopes convert the acoustic sound waves obtained through the chest piece into electrical signals which can then be amplified for optimal listening



The electronic stethoscope - Scientific Figure on ResearchGate. Available from: https://www.researchgate.net/figure/One-state-of-the-art-electronic-stethoscope-16_fig8_279966845

High level Details

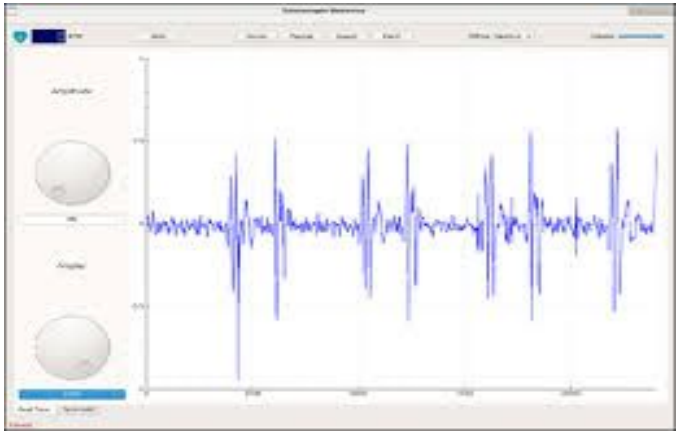
- There are three main modules
  - data acquisition module
  - pre-processing module
  - signal processing module.
- high selective sensitivity
- Smartphone Applications
- Auto-Shutoff
- Ear tip designs



Pic credits: The electronic stethoscope: Shuang Leng, Ru San Tan, Kevin Tshun Chuan Chai, Chao Wang, Dhanjoo Ghista, and Liang Zhong

Low Level –Sound & data acquisition

- Electronic stethoscope sensor commonly used transducers in the stethoscope are microphone, piezoelectric sensors etc.
- Filter & amplifier:
  - anti-aliasing filter
  - Band-pass filter
  - a pre-amplifier with a small gain
- Analog-to-digital converter



Low Level –Heart sound pre-processing module

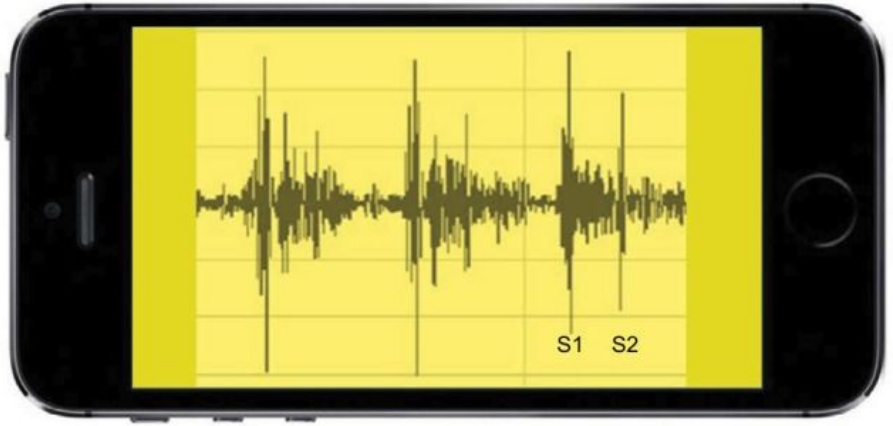
- Signal denoising unit - A digital filter to extract the signal within the frequency band of interest
- Normalization - signals are normalized to a certain scale
- Segmentation - After getting the normalized signals, the HS signals are segmented into cycles

Low Level –Heart sound signal processing module

- Feature extraction à convert the raw data to some type of parametric representation
- Classification àtrained with the extracted features, categorize the data

Low Level –Smart phone application

- Collecting patient data
- Delivery of healthcare information to doctors and patients
- Real-time monitoring of patients vitals
- Mobile telemedicine – direct provision of health care



Limitations of Electronic Stethoscope

- Heart sound are dynamic in nature requires the development of complex algorithms and use of machine learning
- Validation would need to be done with larger datasets and with properly blinded trials
- Cost an important limiting factor

Reference

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Digital BP Monitor

Digital Blood Pressure Monitor

- A device used to measure blood pressure levels, a blood pressure monitor is also referred to as a sphygmomanometer, blood pressure checker or a blood pressure gauge.
- Digital monitors are more popular for measuring blood pressure. They often are easier to use than aneroid units.
- The digital monitor has a gauge and stethoscope in one unit. It also has an error indicator.
- The blood pressure reading displays on a small screen. A digital BP monitor uses an inflatable air-bladder cuff, a battery-powered air pump and a pressure sensor for sensing arterial wall vibrations to measure blood pressure in an artery.
- Users need not pre-set the inflation level before measurement, as an automatic BP machine determines the ideal cuff pressure based on one's systolic blood pressure and arm size.

Types of Digital BP Monitor

There are two types of digital BP monitors:

- Upper-arm-The upper-arm model has a cuff that is placed on the upper arm and is connected by a tube to the monitor that rests on a surface near the arm.

- Wrist models-The wrist model is smaller and the entire unit wraps around the wrist.

Working Principle

- A digital blood pressure monitor uses an air pump to inflate a cuff surrounding an upper arm or a wrist with sufficient pressure to prevent blood flow in the local main artery.
- This pressure is then gradually released using a digitally-controlled solenoid valve until the moment that the blood begins to flow through the artery.
- The blood pressure measured by a pressure sensor at this point determines the systolic pressure. Pulse rate is also sensed at this time.
- The signal from the pressure sensor is conditioned with an instrumentation amplifier before data conversion by an analog-to-digital converter (ADC).
- The systolic pressure, diastolic pressure, and pulse rate are then calculated in the digital domain using an algorithm appropriate for the type of monitor and sensor utilized. The resulting systolic, diastolic, and pulse-rate measurements are displayed on a liquid-crystal display

High Level Details

- Push Button- To turn on the BP monitor.
- Inflatable bladder cuff-The cuff will inflate by itself with a push of a button and deflate automatically.
- Screen-Display screen to get your blood pressure reading
- Pressure sensor- To sense the pressure of the blood.
- Batteries- To provide power to the BP monitor.

Low Level Details

- A digital blood pressure monitor uses an air pump to inflate a cuff surrounding an upper arm or a wrist with sufficient pressure to prevent blood flow in the local main artery.
- The blood pressure measured by a pressure sensor at this point determines the systolic pressure.
- The signal from the pressure sensor is conditioned with an instrumentation amplifier before data conversion by an analog-to-digital converter (ADC).
- The resulting systolic, diastolic, and pulse-rate measurements are displayed on a liquid-crystal display (LCD), time-stamped, and stored in non-volatile memory.
- Upper-arm BP monitors typically use four AA or AAA (1.5V) alkaline batteries and wrist monitors typically use two AAA alkaline batteries.

Pulse Oximeter

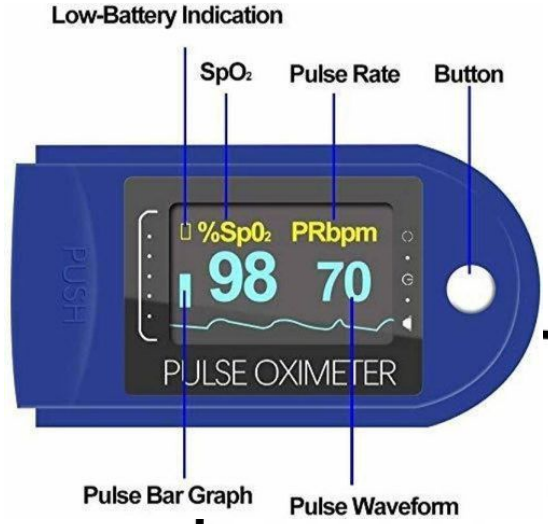
Pulse Oximeter

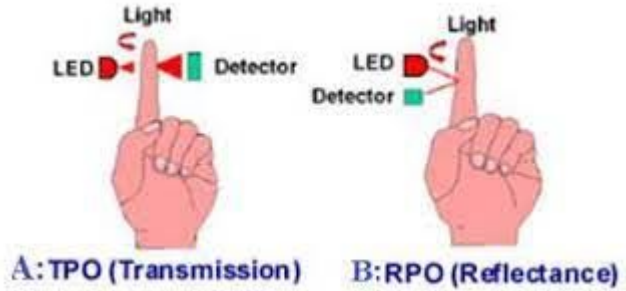
A pulse oximeter is a painless and reliable way for clinicians to measure a person's blood oxygen levels.

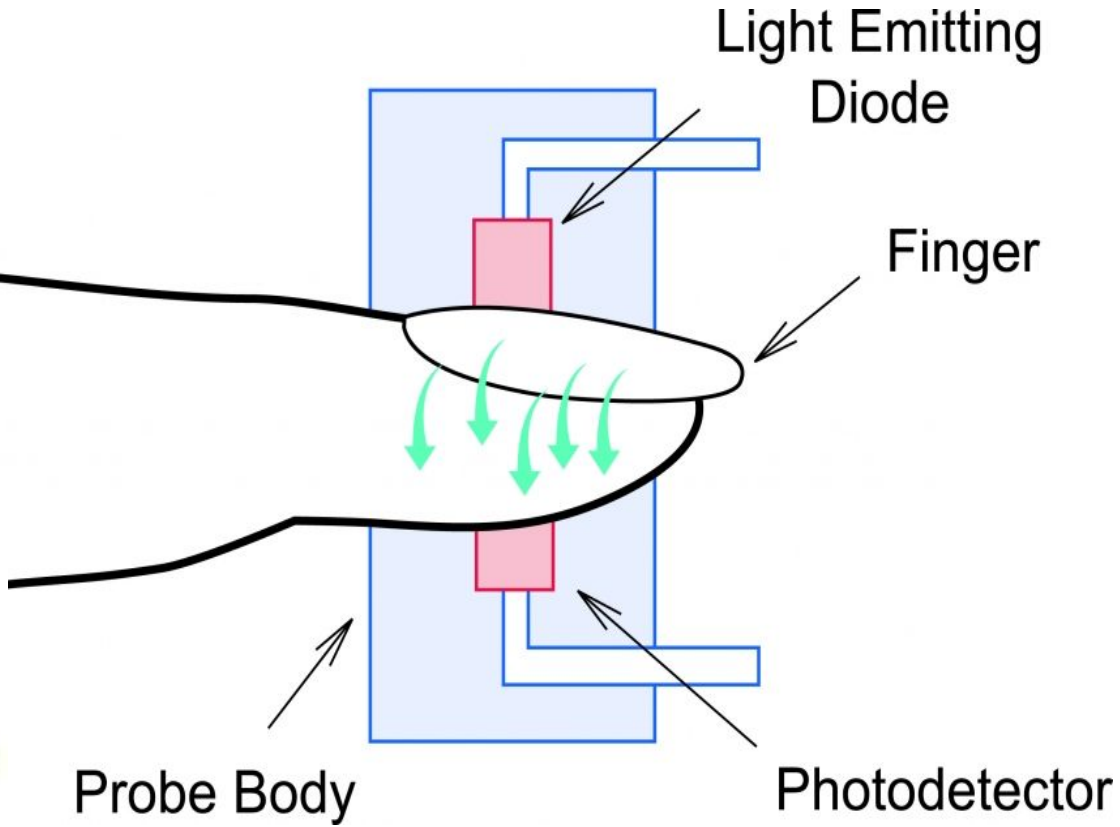
When you breathe, oxygen enters your lungs, passes through thin membranes and enters your bloodstream — where it's then picked up by red blood cells and carried around the body to various organs.

A pulse oximeter is a tiny device that usually slides over your fingertip or clips on your earlobe and uses infrared light refraction to measure how well oxygen is binding to your red blood cells. Oximeters report blood oxygen levels via an oxygen saturation measurement called peripheral capillary oxygen saturation, or SpO2.

Pulse Oximeter(Transmission type)







Pulse Oximeter

High Level details -

- **Pulse oximeter measures oxygen saturation** by illuminating the skin and measuring changes in light absorption of oxygenated (oxyhemoglobin) and deoxygenated blood (reduced hemoglobin) using two light wavelengths: 660 nm (red) and 940 nm (infrared).

- **Display the details on oximeter screen**

Low Level details -

- **Emit red and infrared light** - It is fortuitous that O2Hb and HHb have significant differences in absorption at red and near-IR light because these two wavelengths penetrate tissues well whereas blue, green, yellow, and far-IR light are significantly absorbed by non-vascular tissues and water.
- **Collect them using photodetector** - Photodetectors, also called photosensors, are sensors of light which detects the penetrated light. Oxygenated and deoxygenated hemoglobin have different light absorption rate.

Pulse Oximeter levels

Observation	Oxygen saturation (SpO2) %	Pulse rate (bpm)	Temp (°C)
Normal readings	96% or more	40-100	36.5-37.5
Acceptable to continue home monitoring	95%	101-109	38
Seek advice from your GP	93-94%	110-130	38.1-39
Need urgent medical advice – call 999	92% or less	131 or more	39 or more

Pulse Oximeter

Limitations :

1. Not reliable in patients with poor circulation (e.g. peripheral vascular disease, hypothermia, critically ill pts)
2. Does not work through nail polish, dyes or pigments.
3. Not reliable in patients that have an irregular pulse rate.
4. Shivering and movement give false readings.
5. There have been reports of skin burns (earlier models).

Pulse Oximeter

Vendors throughout the world :

1. Dr Trust USA Fingertip Pulse Oximeter
2. BPL Smart Oxy Lite Pulse Oximeter
3. Vandelay Electronic Fingertip Pulse Oximeter
4. Microtek Pulse Oximeter Health Care Appliance Combo
5. Zebronics Fingertip Pulse Oximeter FP0500

Digital Temperature Monitor

Digital Temperature Monitoring System

Digital Temperature Monitoring System has become important for hospitals, clinics, healthcare and life science organizations, in order to monitor the temperature of the patients.

Based on the practical uses these digital temperature monitoring systems can be Surface Temperature Monitoring System, Infrared Temperature Monitoring Systems, etc.

High Level Details

Providing real time accurate temperature measurements

Convenient digital display

Having proper alarm system to report emergency situations without delay

Low Level Details

Sensors :

RTD sensor provides a change in resistance that is related to temperature. They offer more accurate readings than thermocouples but have a narrower operating range. The most common RTD consists of a fine platinum wire wound around a cylinder — nickel and copper wire are also used.

Thermistors are similar to RTDs, but their resistance change is highly nonlinear. Thermistors can offer very accurate temperature measurements, down to an accuracy of 0.01 °C but only over a very limited temperature range (typically 0 °C to 100 °C).

Thermocouples are the most widely used temperature sensor and also one of the least expensive sensors available. They are widely used where cost, simplicity, and wide operating range are paramount and where extremely high accuracy is not required.

Temperature Measurement Devices:

Temperature measurement devices are connects to the probe to measure and record the temperature.

The measurement device connects to temperature sensors, digitizes the temperature value, performs any local alarm evaluation, and records the reading's memory or transmits it to a server in the case of a network-based system. And finally the output displayed to the user using a temperature data logger.

Temperature Buffers:

A thermal buffer helps smooth rapid temperature fluctuations at the sensor due to compressor cycling, door opening, or loading/ removing products.

Thermal buffers are thermal masses that are attached to the temperature probe to increase the time constant (slow the response time) of the temperature probes in order to more closely match the temperature of the material being stored.

Thank You