

Tecnologie per il monitoraggio non-invasivo dei principali parametri vitali

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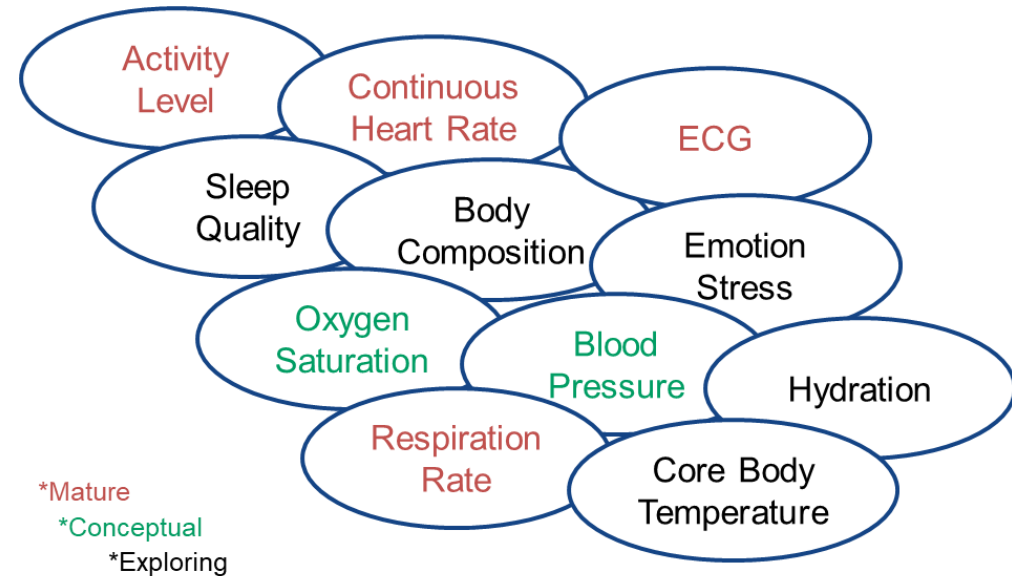
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Agenda

- ❑ Remote monitoring Application Scenarios
- ❑ Vital Signs Monitoring Technology overview
 - ❑ Bio-Potential
 - ❑ Optical
 - ❑ Bio-Impedance
 - ❑ Motion sensing
- ❑ Solution example
- ❑ Q&A

Why measure Vital Signs – Focus on worker/employee monitoring

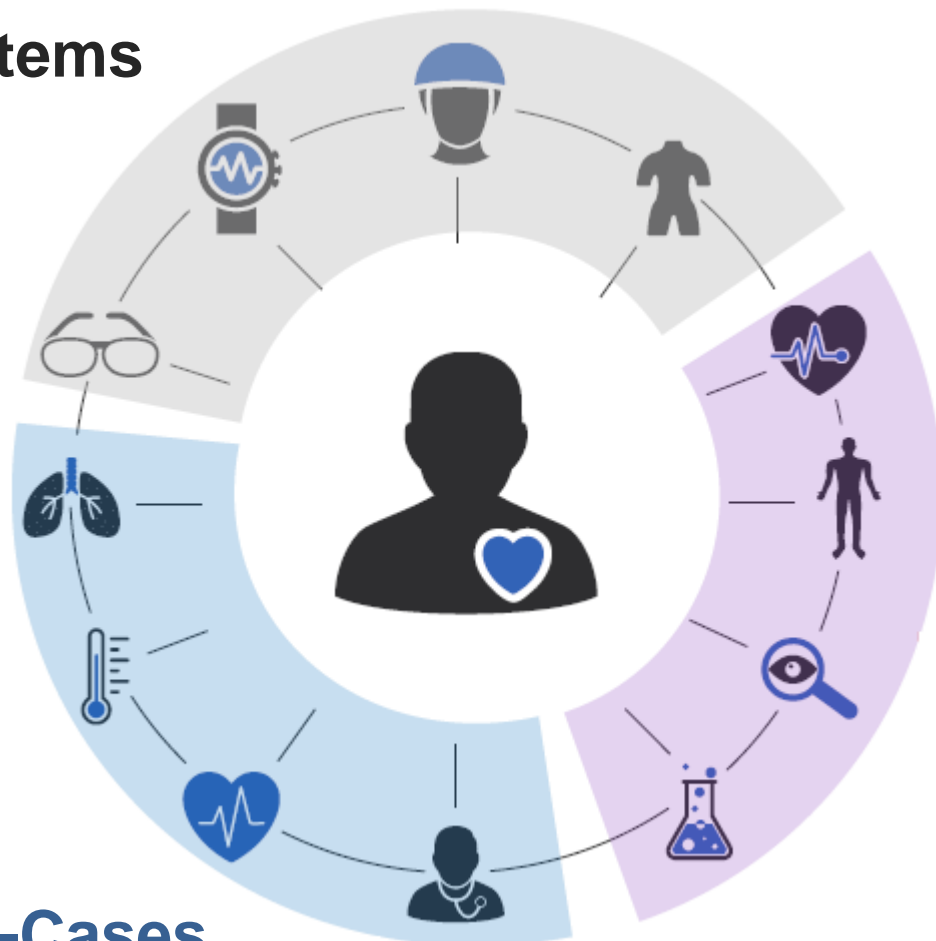
- ❑ Vital Signs are measured to **observe** the condition of a person
- ❑ Vital Signs need to be within a certain **range** (ranges are Age and Activity dependent)
- ❑ Vital Signs allows the **early detection** of potential health issues
- ❑ In addition to the main vital signs, many other additional parameters can give valuable feedback on the **state of health**



“Patient” empowerment

Systems

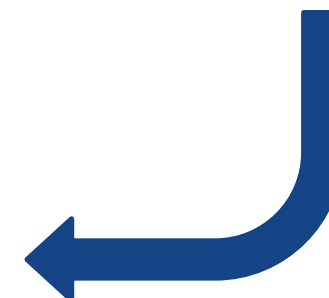
Use-Cases



**Measure &
Sense**



**Collect &
Transmit**



**Review &
Analyze**

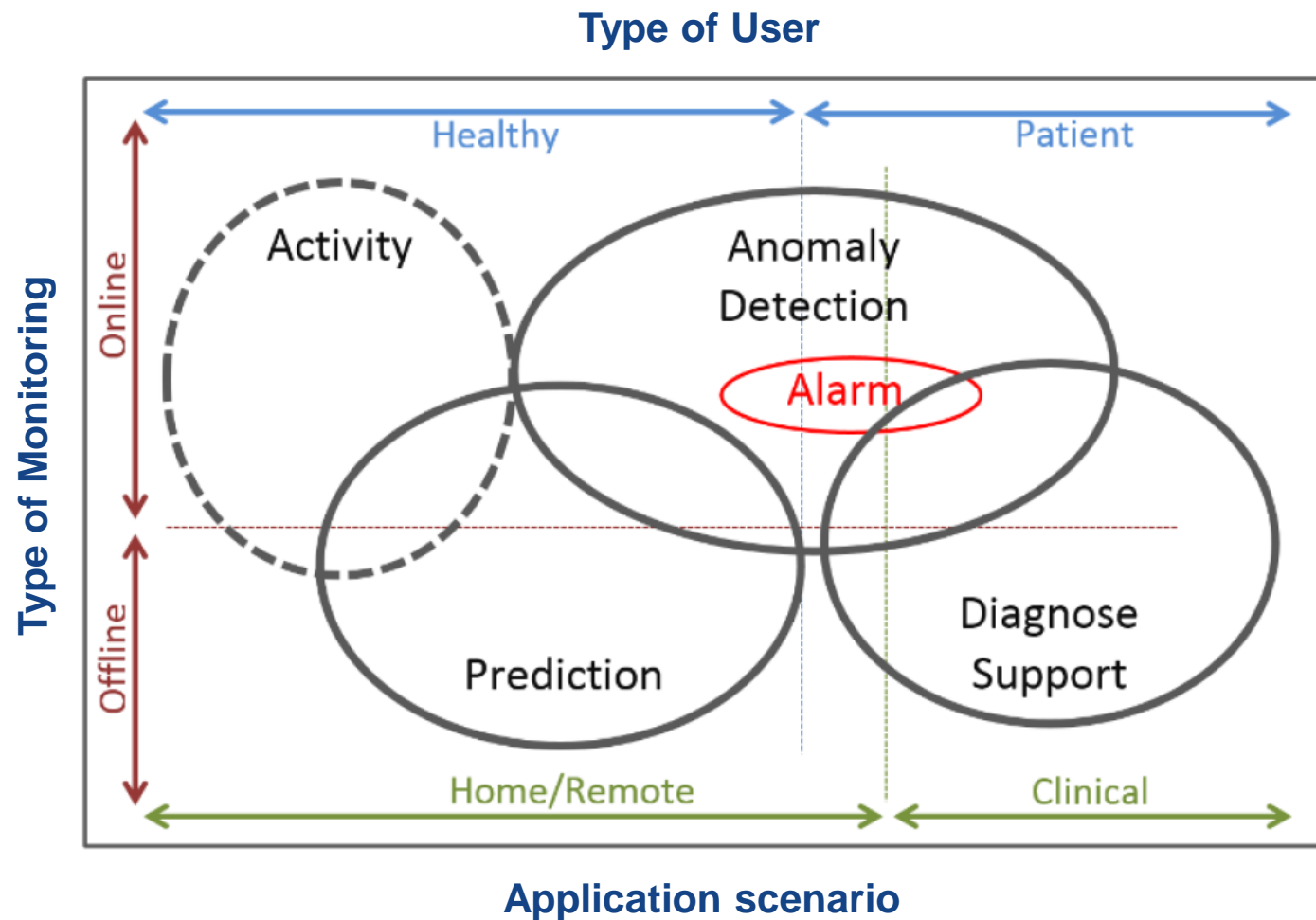


**Feedback &
Prescription**

Technologies



Remote monitoring framework



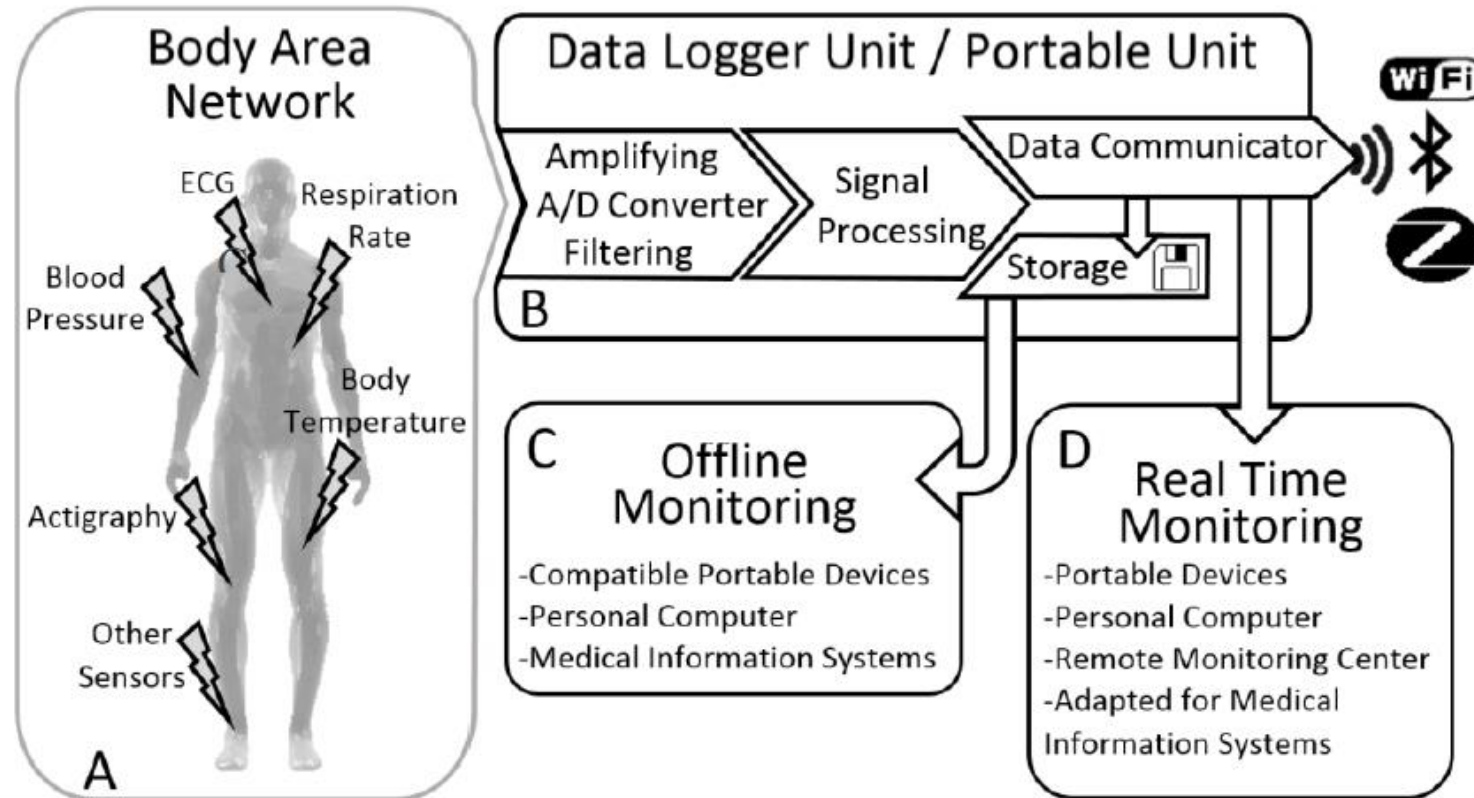
☐ Wellness management

☐ Health and Safety Systems

☐ Disease Management

☐ Clinical Diagnostic

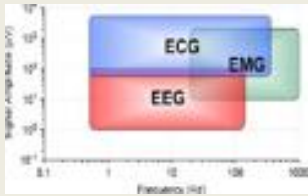
Wearable Health Device – Generic architecture



Generic architecture of wearable health devices system [*]

Vital Signs Monitoring - Technologies

Bio-Potential



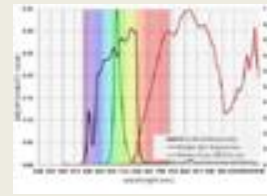
- ECG waveform monitoring
- Heart Rate Monitoring (HRM)
- Heart Rate Variability (HRV)
- Atrial Fibrillation (AFIB)
- ExG Other

Bio-Impedance



- Galvanic Skin Response (GSR)
- Bio-Impedance Analysis
- Respiration Rate
- IPG
- Hydration level

Optical



- Oxygen Saturation (SpO2)
- Heart Rate Monitoring (HRM)
- Heart Rate Variability (HRV)
- Non-Invasive Cuff-less blood pressure (NiCBP) with PWTT

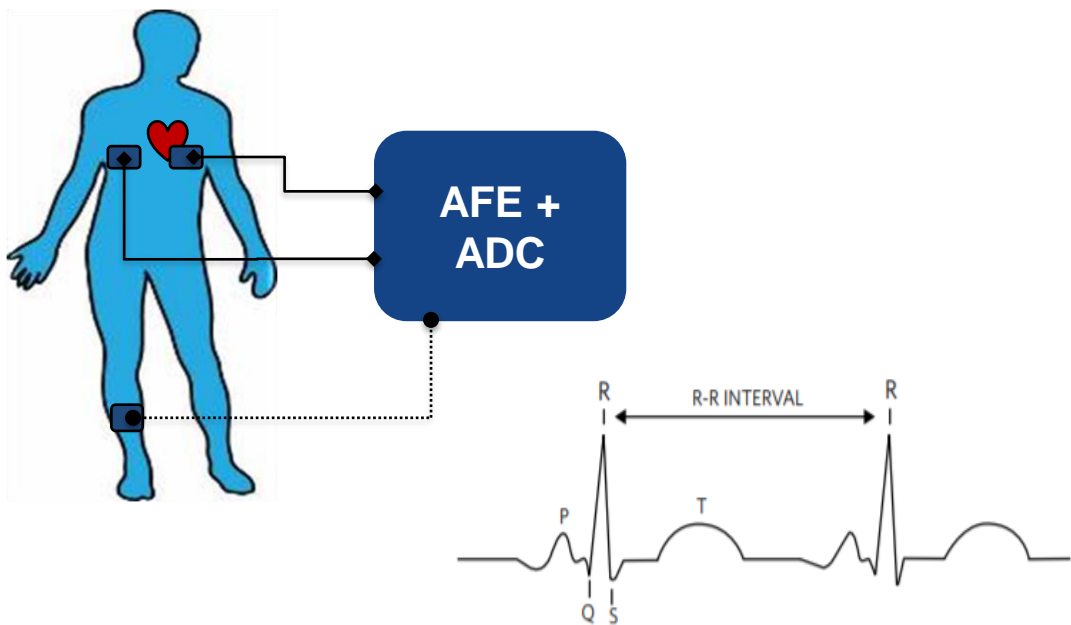
Motion



- Activity tracking
- Motion Profiling
- Fall Detection
- Motion Artifact cancellation

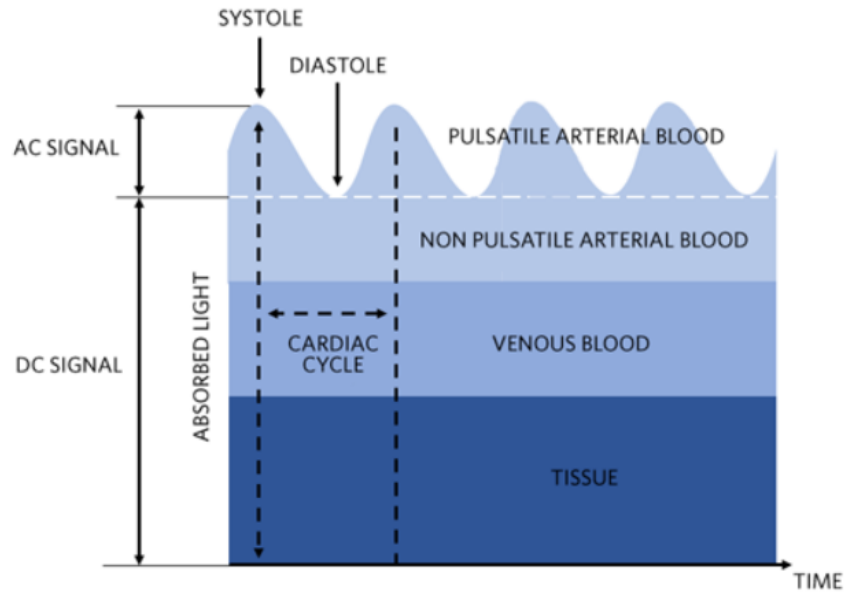
Bio-Potential measurement

- ❑ **BIO-POTENTIAL** is an electric potential that is measured between points in living cells, tissues, and organisms, and which accompanies all biochemical processes

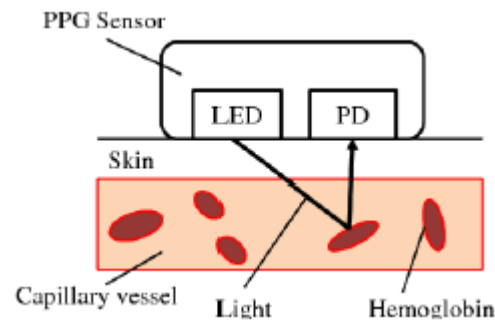


- ❑ **ECG** is one of most valuable biopotential measurement, provides an insight into the electrical activity generated within heart muscles
- ❑ **Single-lead ECG** is the minimum configuration for ECG waveform acquisition and R-R interval calculation for HRM/HRV
- ❑ **Electrodes:**
 - ❑ **Wet** for clinical use
 - ❑ **Dry** for wearable applications (wrist-band, chest-belt, chest-strap, T-Shirt)
- ❑ **Signal processing and data conversion:**
 - ❑ Integrated Analog Front End with high input impedance, low noise, high CMRR and programmable filter.
 - ❑ High resolution analog-to-digital converter

Optical measurement



Light absorption diagram of the skin and corresponding DC and AC levels.



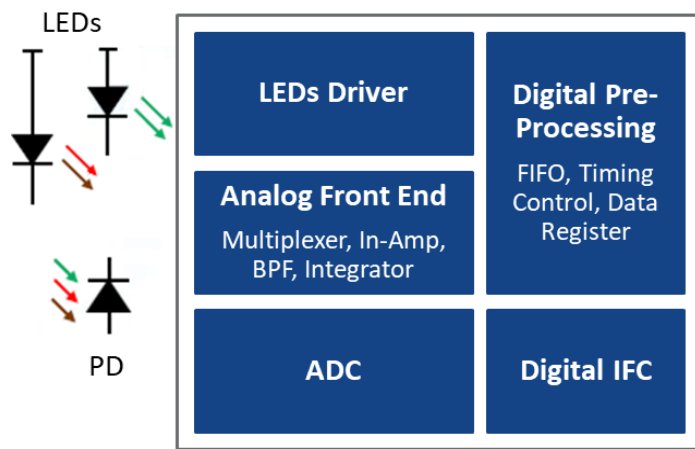
PPG Reflective measurement topology.

- ❑ **Photoplethysmography (PPG)** is a non-invasive method that uses a light source (LEDs) and a photodetector (PD) placed at the surface of skin, to measure the volumetric variations of blood circulation. PPG methods are used to quantifying parameters related with the cardiovascular and respiratory systems.
- ❑ **Transmissive** measurement: Light source and detector on the opposite side
- ❑ **Reflective** measurement: light source and detector arranged in the same plane (see figure)
- ❑ **Measurement extraction** with optimized algorithms
 - ❑ Heart Rate (HRM)
 - ❑ Heart Rate Variability (HRV)
 - ❑ Blood Oxygen Saturation (SpO2)
- ❑ Each body location and measurement types need **proper LED wavelength**

Optical measurement

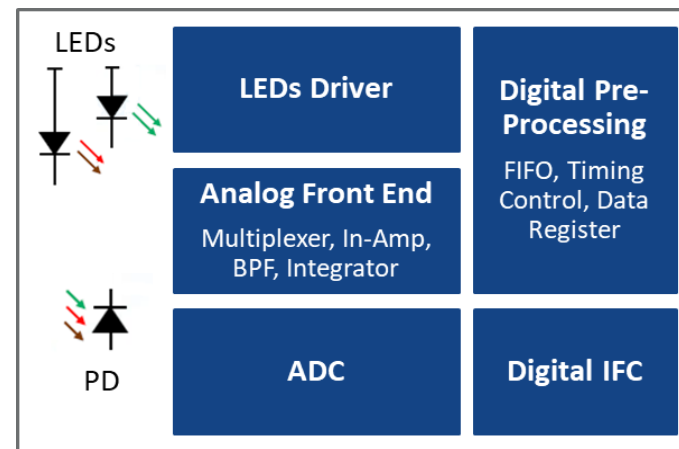
❑ Discrete Solution

- ❑ Analog Front End with External LEDs and PD
- ❑ Flexible in LED wavelength(s) selection
- ❑ Optimization possible for LEDs and PD body placement
- ❑ Requires Optical/Mechanical and Electronic Design resources

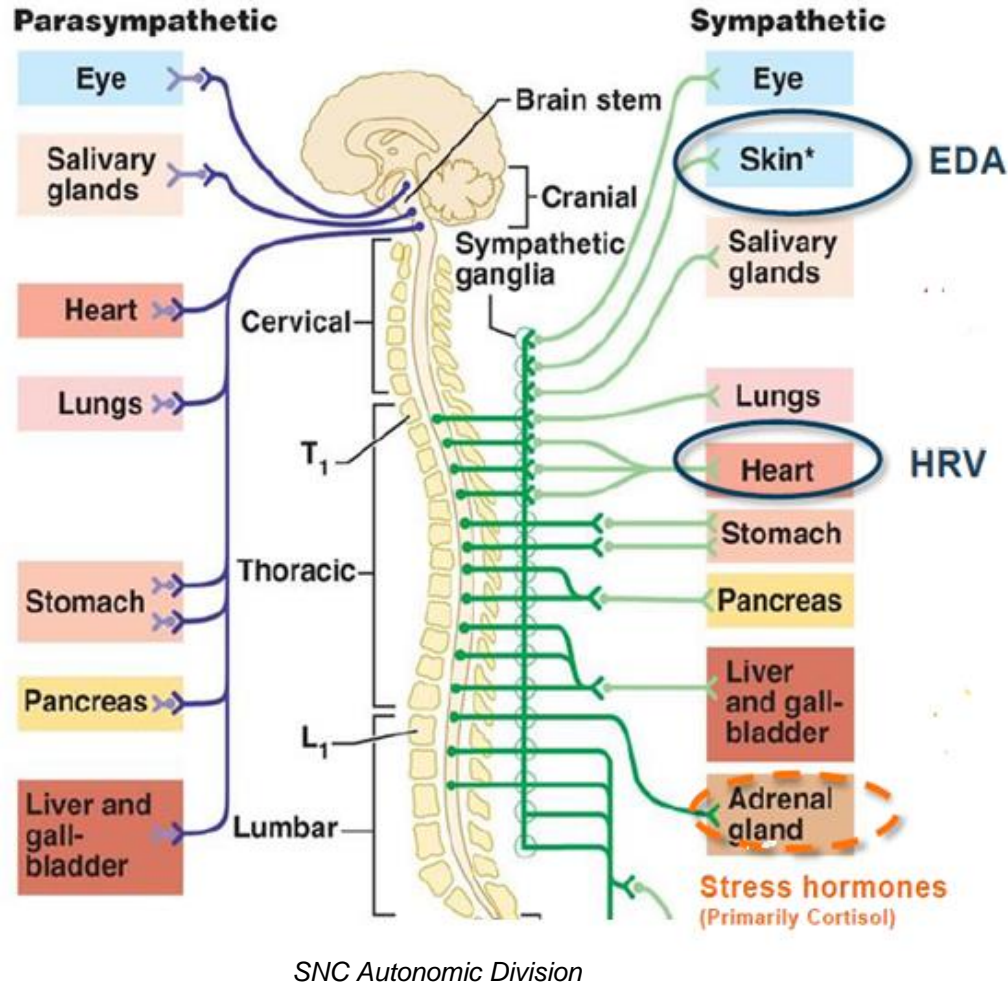


❑ Integrated Module

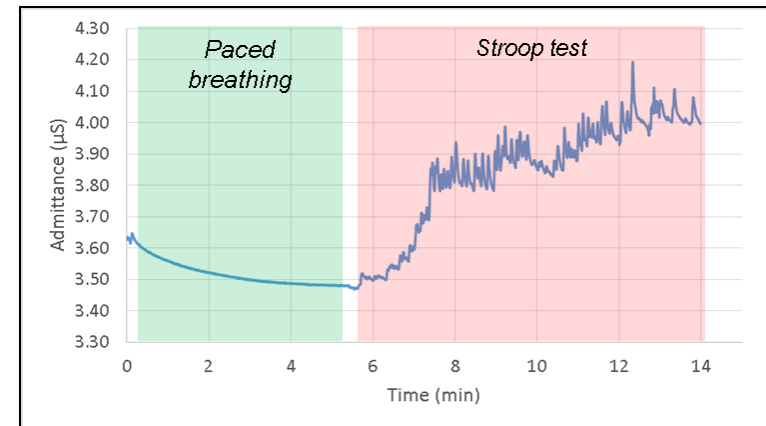
- ❑ Single Package with integrated Analog Front End, LEDs and PD
- ❑ Application specific configuration
- ❑ Small Form Factor and faster time to market
- ❑ Less design knowledge, no need to optimize the light path (Optimized optical crosstalk)



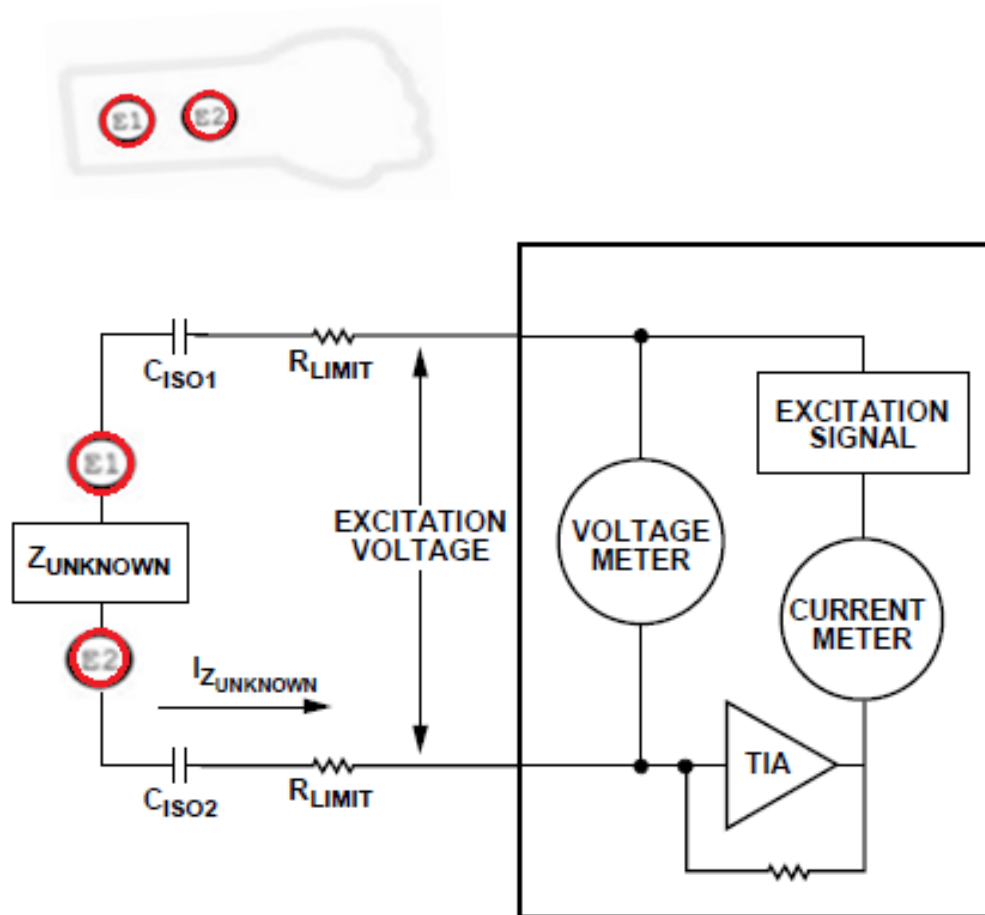
Bio-Impedance measurement



- ❑ **Galvanic Skin Response (GSR)**, also named **Electrodermal Activity (EDA)** is the measure of the continuous variations in the electrical characteristics of the skin (*conductance*), caused by the variation of the human body sweating.
- ❑ **EDA/GSR** is considered a way to monitor the autonomic nervous system (SNA) in particular the sympathetic component. It is well known also the relationship between SNA and stress



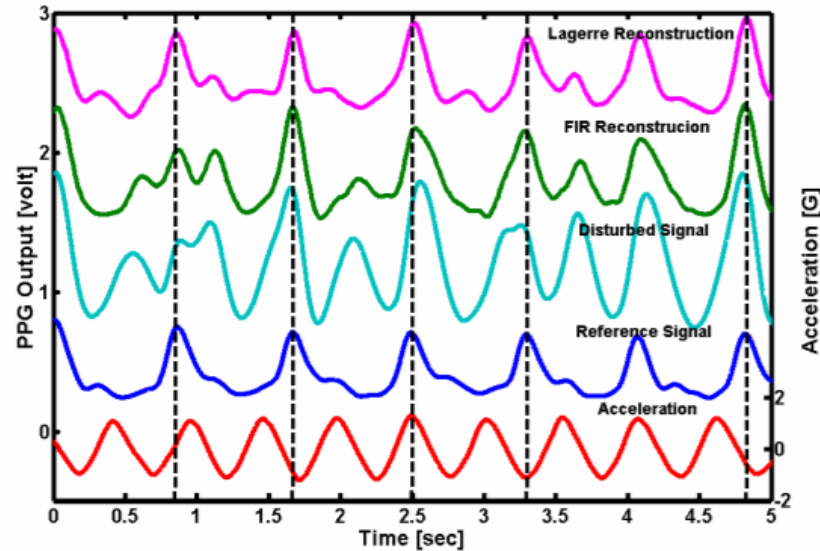
Bio-Impedance measurement - EDA



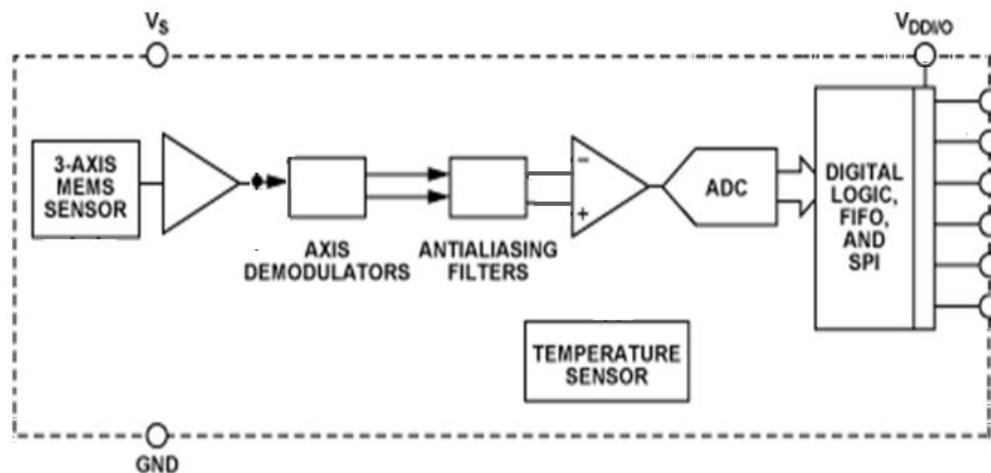
2-wire EDA measurement setup with electrodes position example on wrist

- ❑ **2-Wire** relative measurement
- ❑ Generate AC **Excitation Voltage** and Measure the **Current Response**
- ❑ **Low Frequency excitation** waveform (below 200Hz)
- ❑ **Always on** application – continuous monitoring
 - ❑ Low current consumption target below 100uA
- ❑ Same electrodes consideration as for ECG signal acquisition
- ❑ Each impedance measurement on the human body must comply with **IEC 60601 standard**, for the maximum allowable current.

Motion Sensing









Motion artifact removal example on PPG signal



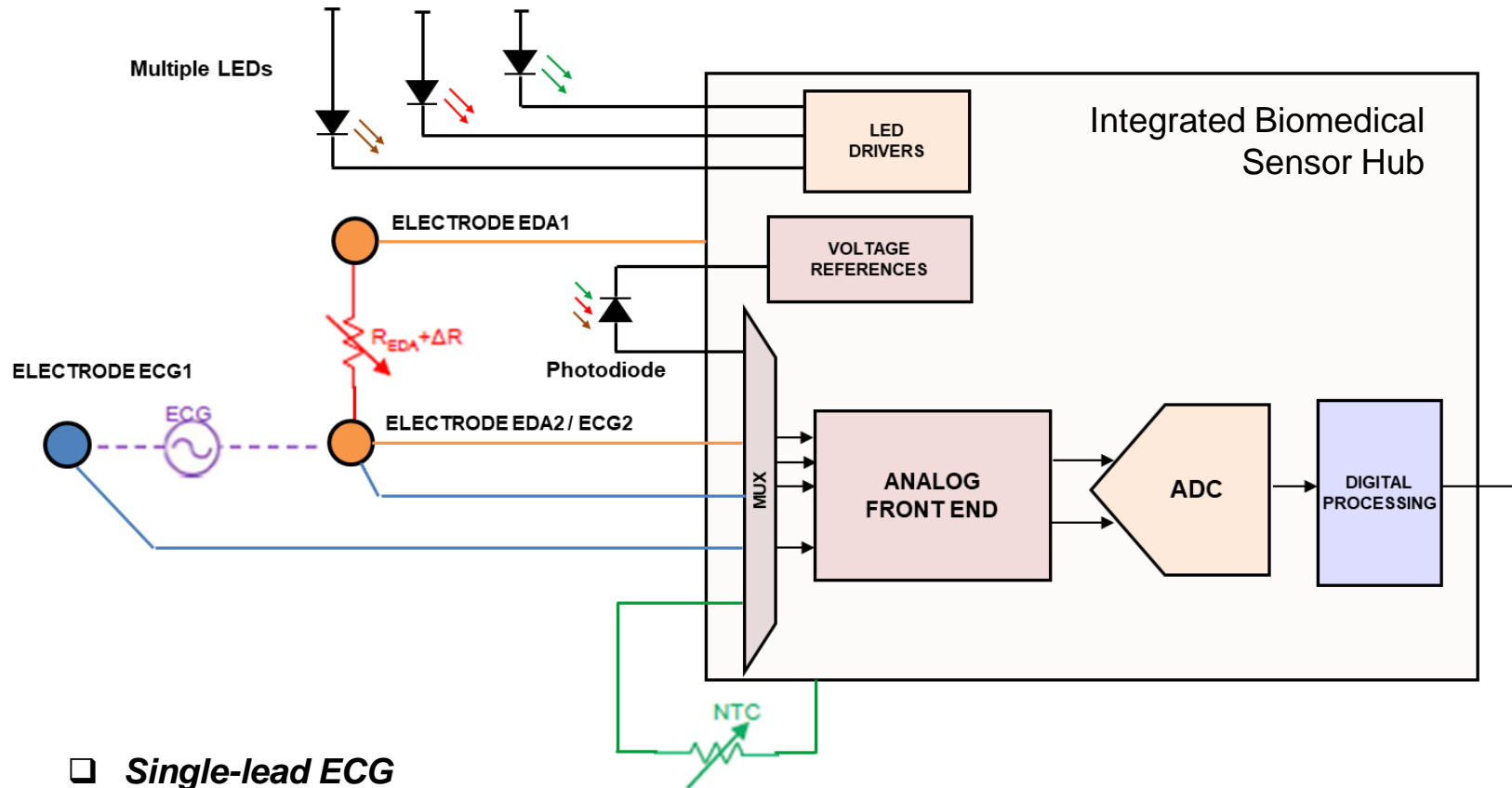
3-Axis MEMS Digital accelerometer block scheme example

- ☐ **Motion sensing** is crucial in vital signs monitoring application
 - ☐ Activity detection
 - ☐ Fall detection
 - ☐ Injury and shock monitoring and analysis
 - ☐ Posture assessment
- ☐ **Artifact Removal** with motion rejection is mandatory in Optical measurement and suggested in Bio-potential and Bio-impedance measurement
- ☐ All the above-mentioned features could be achieved with **low power MEMS sensors**
 - ☐ 3-axis accelerometers
 - ☐ 6 to 9 DoF IMU (Accelerometer, Gyroscope, Magnetometer)

Vital Signs, Technologies and Solution – Summary

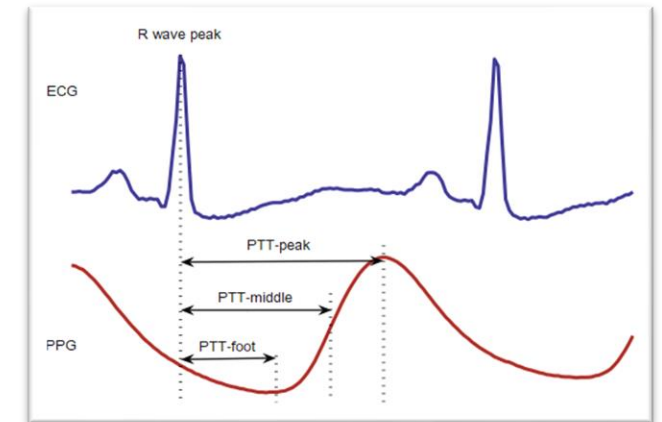
	Use-Case	Technology	Solution
	<ul style="list-style-type: none"> Heart Rate Monitoring (HRM) / Variability (HRV) ECG waveform 	<ul style="list-style-type: none"> Bio-Potential / Optical (PPG) Bio-Potential 	<ul style="list-style-type: none"> ECG Analog Front End / Optical Module (Green LEDs) / Sensor Hub Single or multi-lead ECG AFE
	<ul style="list-style-type: none"> Respiration Rate Oxygen Saturation (SpO2) 	<ul style="list-style-type: none"> Impedance Motion sensing Optical 	<ul style="list-style-type: none"> Impedance Front End (DAC + ADC) MEMS or Piezo Optical Module (R/IR LEDs) or AFE + External LEDs + PD
	<ul style="list-style-type: none"> Skin Temperature 	<ul style="list-style-type: none"> Contact measurement Non-contact measurement 	<ul style="list-style-type: none"> RTD or Digital temperature sensor with 0.1°C accuracy IR Temp Sensing
	<ul style="list-style-type: none"> Activity Tracking Motion Profiling Fall Detection 	<ul style="list-style-type: none"> Motion Sensing (MEMS) Piezo sensors 	<ul style="list-style-type: none"> Low power, Low Noise 3-axis accelerometer 6 to 9 DoF IMU Non-contact: (<i>3D Time of Flight sensor</i>)
	<ul style="list-style-type: none"> Stress evaluation 	<ul style="list-style-type: none"> Skin Impedance (GSR) Heart Rate Variability (Bio-Potential or Optical) 	<ul style="list-style-type: none"> Impedance Front End ECG Analog Front End / Optical Module (Green LEDs) / Sensor Hub
	<ul style="list-style-type: none"> Non-Invasive Cuffless Blood Pressure (NiCBP) 	<ul style="list-style-type: none"> Pulse Transit Time (Optical PPG + ECG) Optical PPG only, with waveform evaluation 	<ul style="list-style-type: none"> Sensor Hub (single-lead ECG + PPG synchronized)

Biomedical Sensor Hub – An Example



- ☐ Single-lead ECG
- ☐ EDA
- ☐ PPG
- ☐ SpO2
- ☐ NiCBP
- ☐ Skin Temperature

☐ **Signal synchronization**
(i.e ECG + PPG for Pulse Transit Time)



[*] Source: Jermana L. Moraes et al.; Advances in Photoplethysmography Signal Analysis for Biomedical Applications; Sensors 2018

Q&A

Thank You

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