Senior Design Project (SDP) Competition
Category No. 1: Communications and Electronics

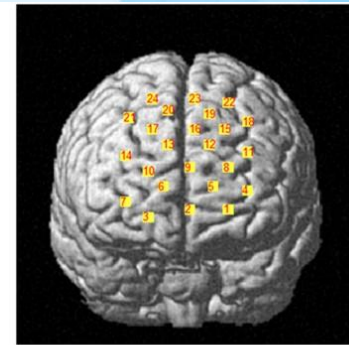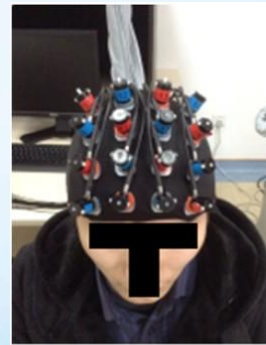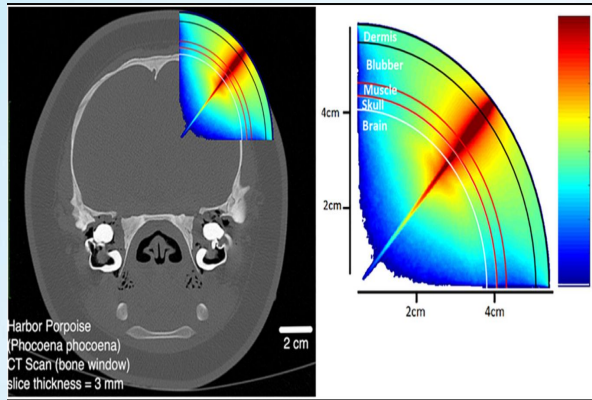# Near Infrared Spectroscopy System for Brain Activities Monitoring

Electrical and Communications Engineering Department
United Arab Emirates University

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Speaker: Lina Alkhatib

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objectives

❖ *Diagnosing diseases with a non-invasive and safe method.*

❖ *Brain activity test using NIRS.*

❖ *Define the NIRS system, how it would be used and Why we choose the NIRS.*

Near Infrared Spectroscopy system (NIRS)

What is NIRS?

▶ Real time sensing technique that uses near infrared light to monitor Oxygen, (HbO2), and (Hb) in the blood and the organic tissues.

▶ NIRS can be applied to different muscles, the bladder and most important the brain.

▶ NIRS has proved to be a non-invasive and safe way of detecting chromophores concentrations since no ionizing radiations or hazardous electromagnetic waves are involved.
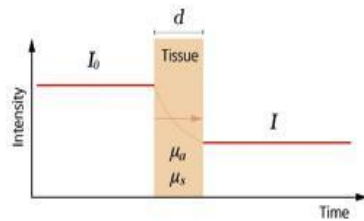
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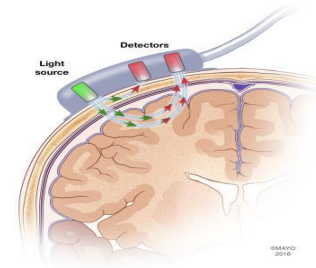
NIRS types
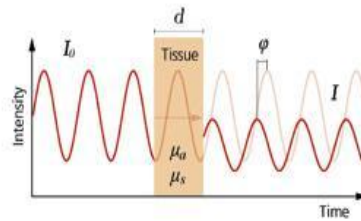
NIRS types

- ► Continuous wave NIRS (CW-NIRS)
- ► Frequency domain NIRS (FD-NIRS)
- ► Time domain NIRS (TD- NIRS)

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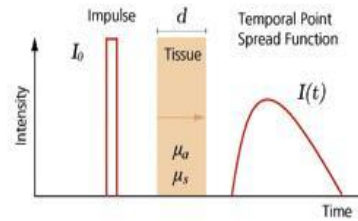
Applications

NIRS in medical diagnosis

Cardiovascular Risk Prediction

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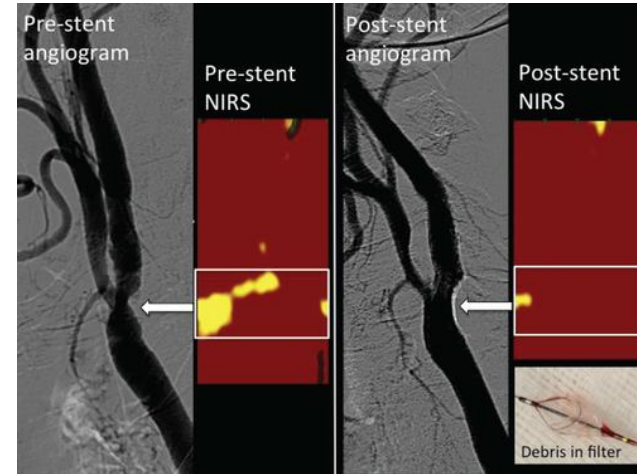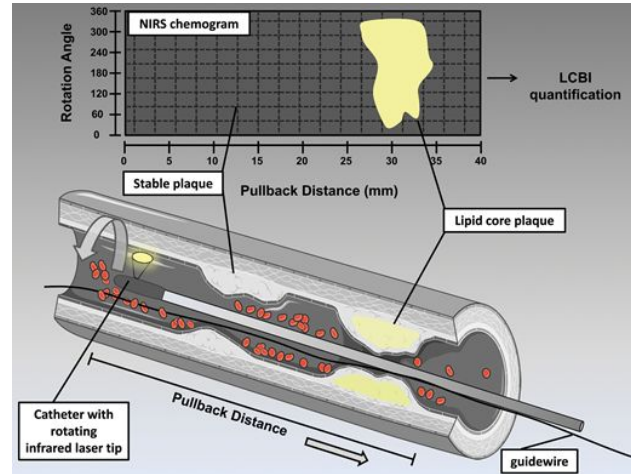
Applications

NIRS in medical diagnosis

Surgery Brain Monitoring

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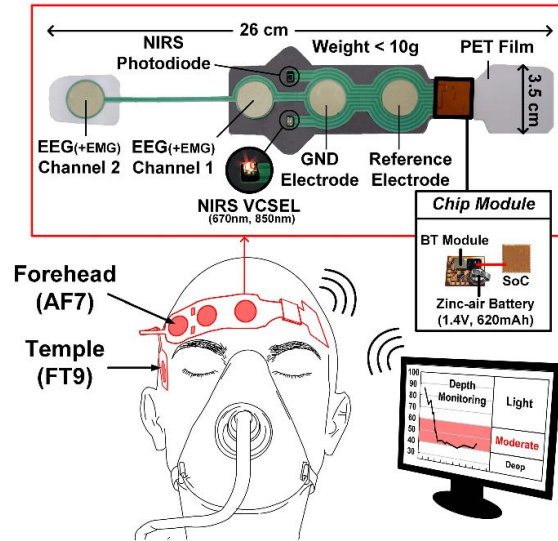
Applications

NIRS in medical diagnosis

Skin Cancer Detection

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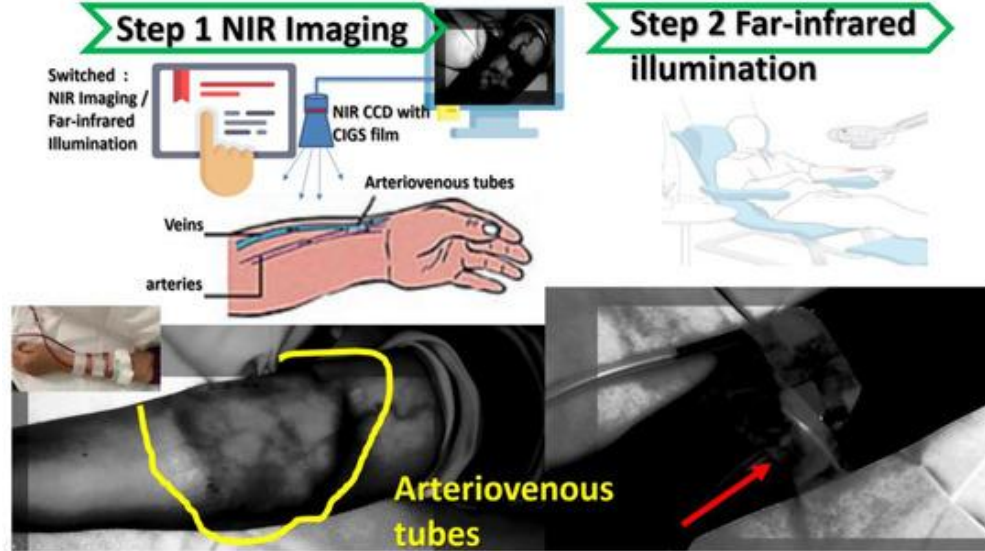
NIRS for brain monitoring

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Brain Monitoring

Why NIRS is better

- Positron emission tomography (PET)
- Magnetoencephalography (MEG)
- Electroencephalography (EEG)
- Functional near-infrared spectroscopy (fNIRS)

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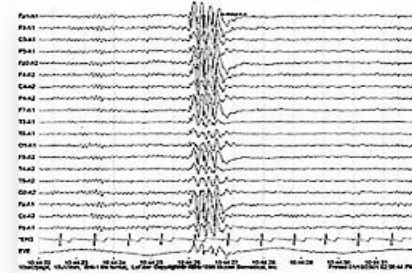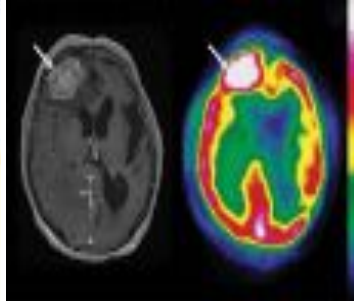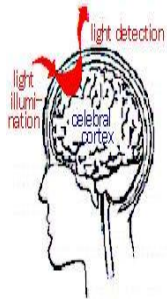
Why NIRS?
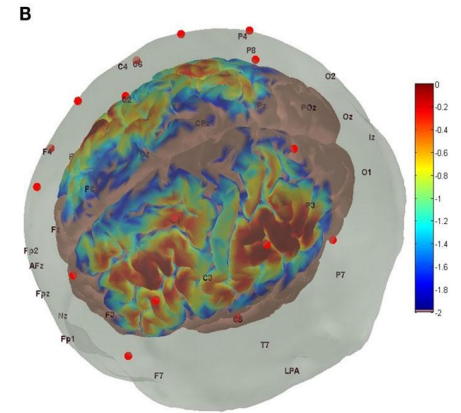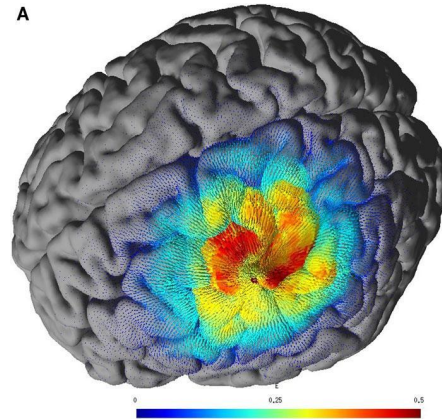
NIRS System block Diagram

Block Diagram
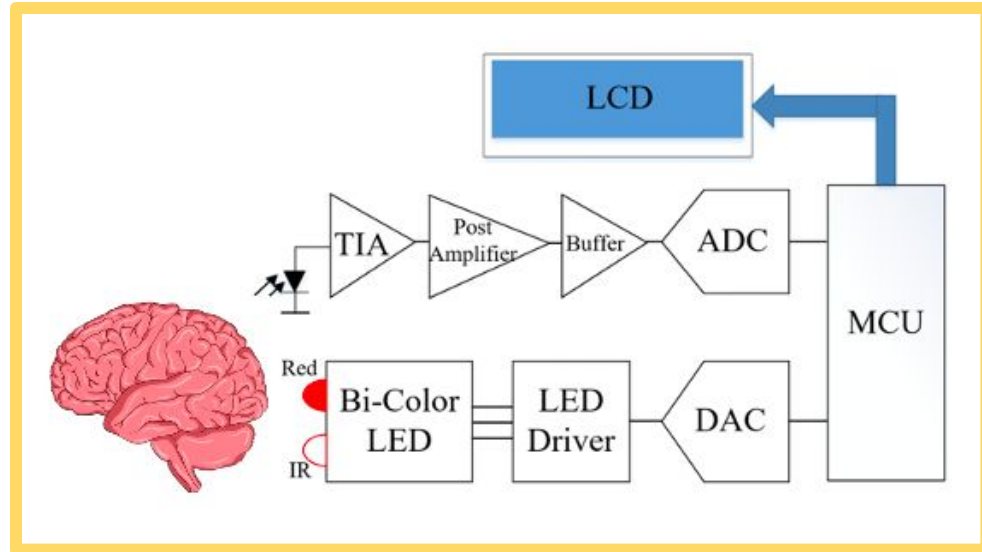
Commercial biosensors

Commercial biosensors
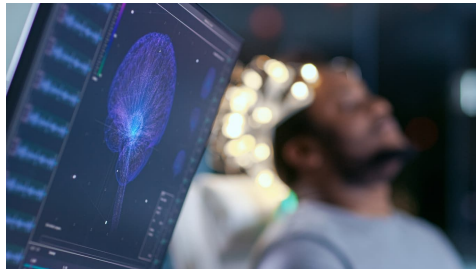
Product	Company	Channel	Bio Sensors	Data Transfer	System Cost ($)
1.Photon Caps	Cortivision [60]	40	NIRS	Bluetooth	$29,013.23
NIRSIT	OBELAB[53]	15	NIRS	Bluetooth wireless connection	$22,000
3.PortaLite	Artinis[47]	4	EEG EMG t.DCS NIRS ECG	Bluetooth Or offline measurments	$11,970.58
5. OctaMon / OctaMon+	Artinis[47]	8	EEG EMG t.CS NIRS	Bluetooth connection or offline recording	$151,132.50

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Systems description

Software Component & Hardware Component

Software Component

Hardware Component

Systems description – Software - MATLAB

Flow chart of MATLAB

```
┌─────────────────────────────┐          ┌──────────────────────────────────────┐
│ Load the data file and read │          │ Baseline (λ) = mean ( Baseline         │
│ into an array 'A'           │          │ sample (λ)) Use Eqs to calculate for   │
│                             │          │ all two ΔHb, ΔHb02 and Δ Hbt for all   │
└─────────────────────────────┘          │ channels                               │
              │                          └──────────────────────────────────────┘
              ▼                                          │
┌─────────────────────────────┐                          ▼
│ Separate two markers from   │          ┌──────────────────────────────────────┐
│ the data                    │          │ Calculate maximum two ΔHb, ΔHb02 and   │
└─────────────────────────────┘          │ Δ Hbt and minimum two ΔHb, ΔHb02 and   │
              │                          │ Δ Hbt values for all channels          │
              ▼                          └──────────────────────────────────────┘
┌─────────────────────────────┐                          │
│ Separate the data from      │                          ▼
│ 730 nm , 850 nm , and time  │          ┌──────────────────────────────────────┐
│ in array A and read into    │          │ Plot the ΔHb, ΔHb02 and Δ Hbt  for all │
│ A730 A850 , and time        │          │ channels and save the results          │
│ respectively.               │          └──────────────────────────────────────┘
└─────────────────────────────┘                          │
              │                                           ▼
              ▼                          ┌──────────────────────────────────────┐
┌─────────────────────────────┐          │ Calculate average baseline ΔHb,        │
│ Baseline sample = Start to   │          │ ΔHb02 and Δ Hbt breath hold time, and  │
│ Marker 1                     │          │ time to reach maximum Hbt  after       │
│ Breath hold sample =         │          │ breath release                         │
│ Marker 1 to Marker 2         │          └──────────────────────────────────────┘
└─────────────────────────────┘
```
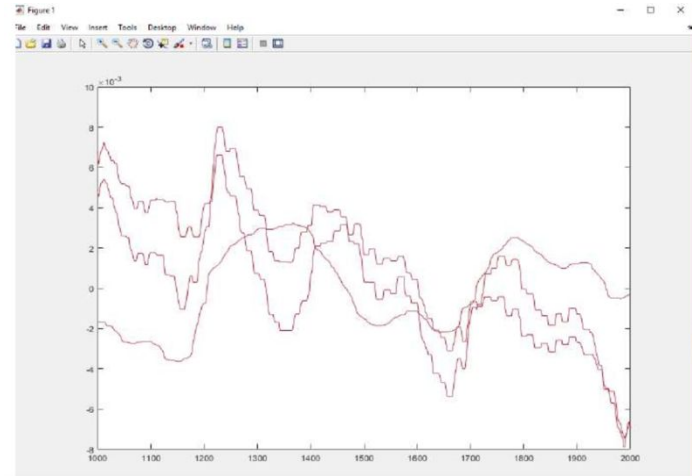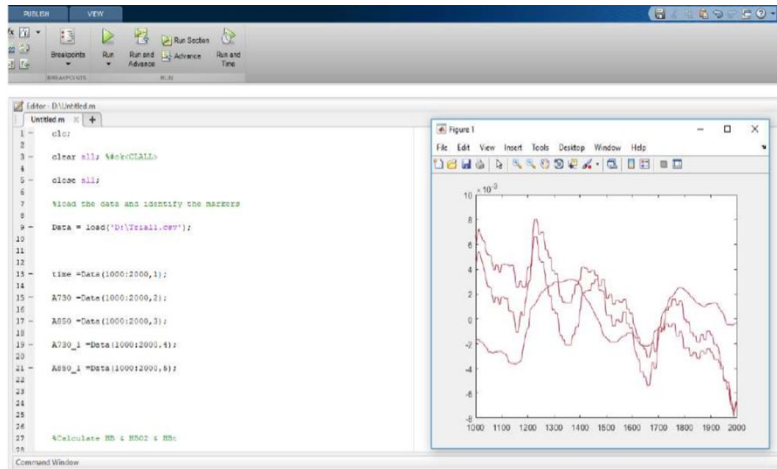
$$\Delta HbO_2 = [- 0.6740 \log(\frac{I^b(\lambda_{850nm})}{I^s(\lambda_{850nm})}) + 1.1171 \log(\frac{I^b(\lambda_{730nm})}{I^s(\lambda_{730nm})})]/L$$

$$\Delta Hb = [- 0.3758 \log(\frac{I^b(\lambda_{850nm})}{I^s(\lambda_{850nm})}) + 0.9943 \log(\frac{I^b(\lambda_{730nm})}{I^s(\lambda_{730nm})})]/L$$

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Systems description – Software - MATLAB

MATLAB code results

▶ *Plot of Hb, HbO2, and Hbtotal for all Channel*

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Systems description – Software

Arduino Due

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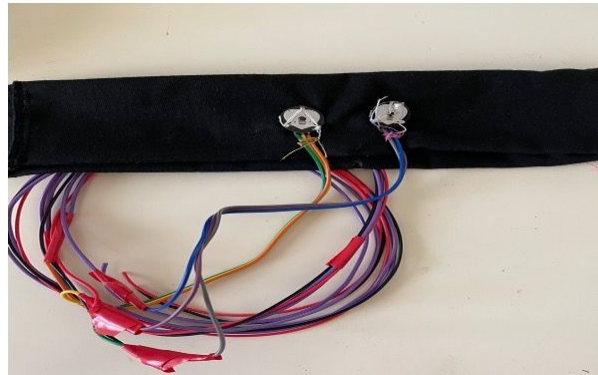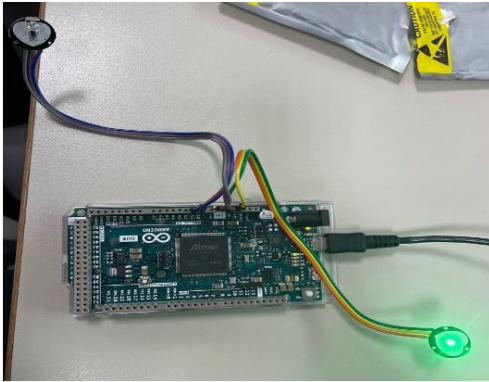
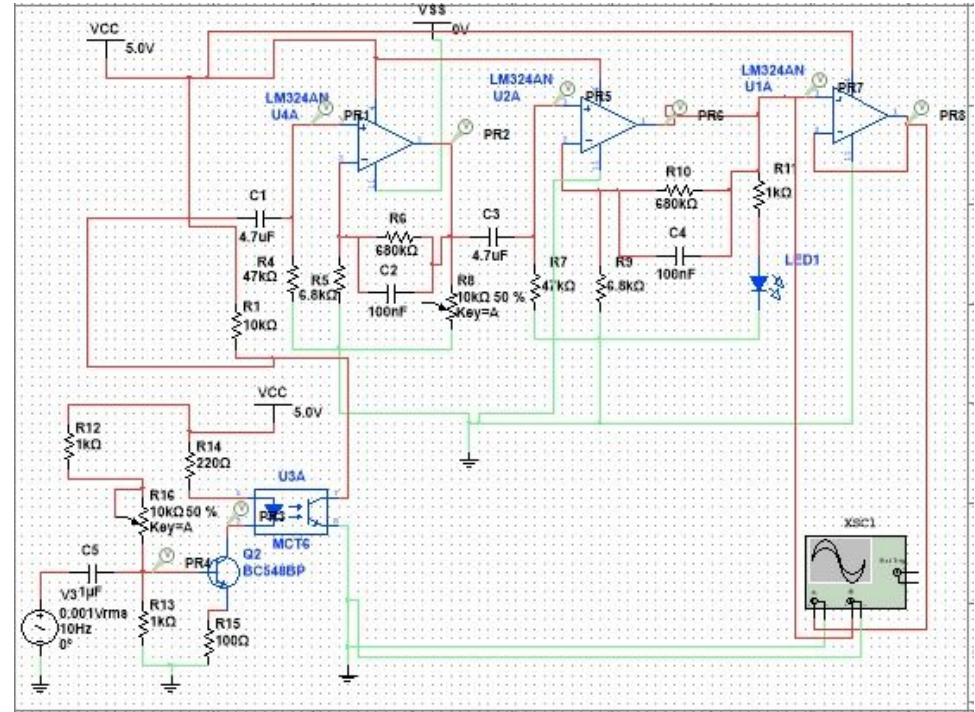# Systems description – Hardware - NI Multisim

Overall circuit layout in NI Multisim.

Stage 1: Transmit the two wavelengths one at a time to the brain tissues, reflect them back and detect them by PD (AC component and a DC component).

Stage 2: The output current of the PD is fed to the TIA where it is amplified and is converted into an output voltage.
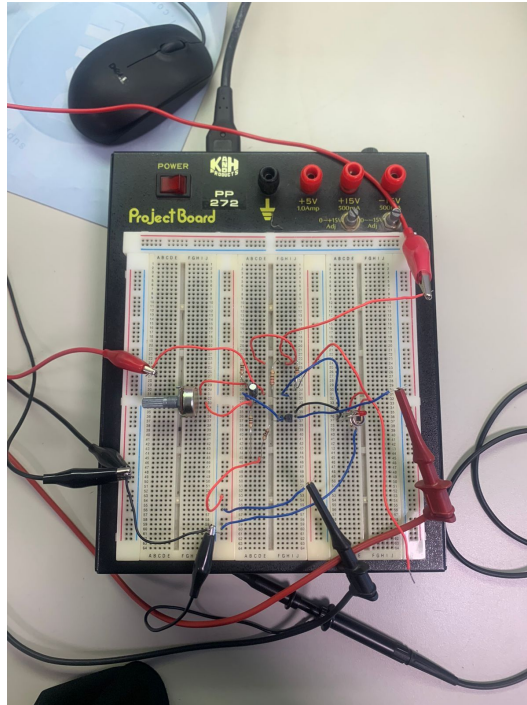
Stage 3: A post amplifier is used for further amplification and filtering.

Stage 4:An output buffer is used for more amplification.

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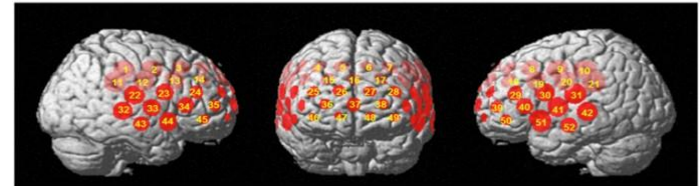# Systems description – Hardware

Transmitter circuit
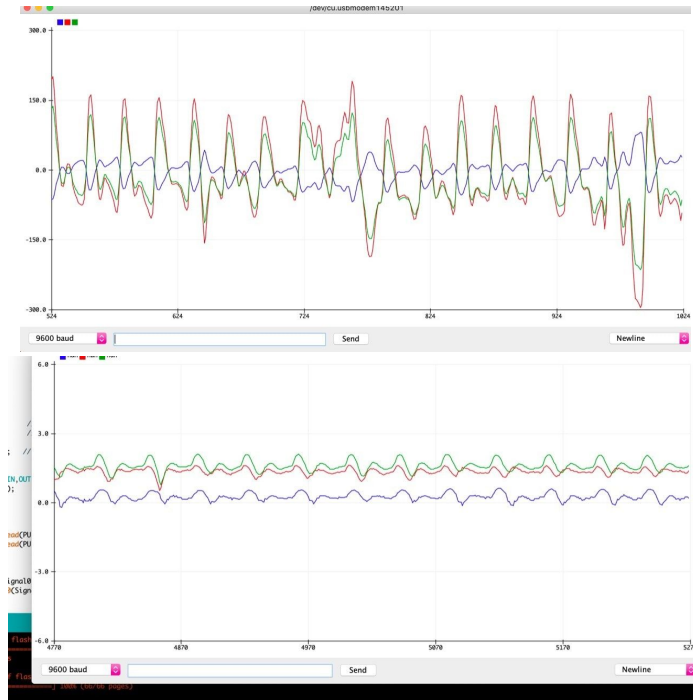

(a) Right Temporal   (b) Frontal   (c) Left Temporal

Systems description – Hardware

The Signal

▶ 2A80008 PULSE SENSOR HEART RATE SENSOR PULSE SENSOR

https://www.blue-pcb.com/products/pulse-sensor-heart-rate-sensor-pulsesensor-module?cmp_id=14272058589&adg_id=129756722630&kwd=&device=c&gclid=Cj0KCQjw8eOLBhC1ARIsAOzx5cEyEfJ3TNxXr7e2RtHW7Rh4TSx_rTbViGk4Q-waP72P1DVdaWdZ4AcaAv0JEALw_wcB

Systems description – Hardware

Headband

► *The handmade headband*

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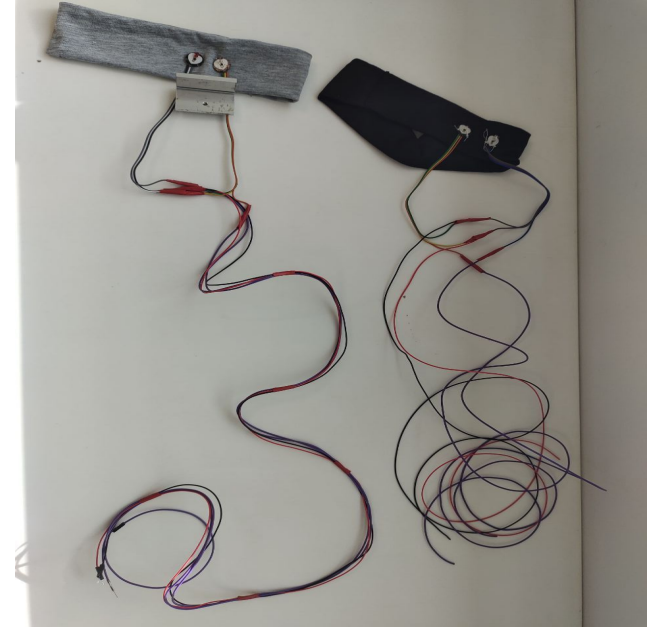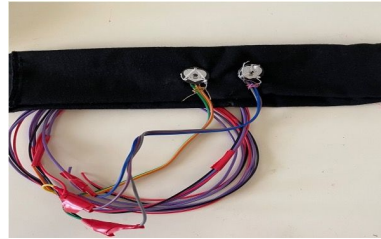
Meet Our Team
5 People

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Communication Engineer

Nada Almazrouei
Electrical Engineer

Mahra Alhamoudi
Communication Engineer

Wadima Alkaabi
Electrical Engineer

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Photos resources

- https://soterixmedical.com/research/nirsit
- http://www.researchimaging.pitt.edu/content/near-infrared-spectroscopy-nirs-brain-imaging-laboratory
- https://www.spectroscopyeurope.com/article/measuring-brain-activity-using-functional-near-infrared-spectroscopy-short-review
- https://www.sciencedirect.com/topics/neuroscience/near-infrared-spectroscopy
- https://academic.oup.com/eurheartj/article/35/5/263/489436
- https://www.jacc.org/doi/full/10.1016/s0735-1097%2814%2961834-9
- https://www.semanticscholar.org/paper/An-EEG-NIRS-Multimodal-SoC-for-Accurate-Anesthesia-Ha-Lee/294549cae6b3568472441ce7f1e57470aae6215b
- https://www.mdpi.com/1424-8220/20/9/2521/htm

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