Integration of wearable technologies, creative integration and artificial intelligence for cardiac care

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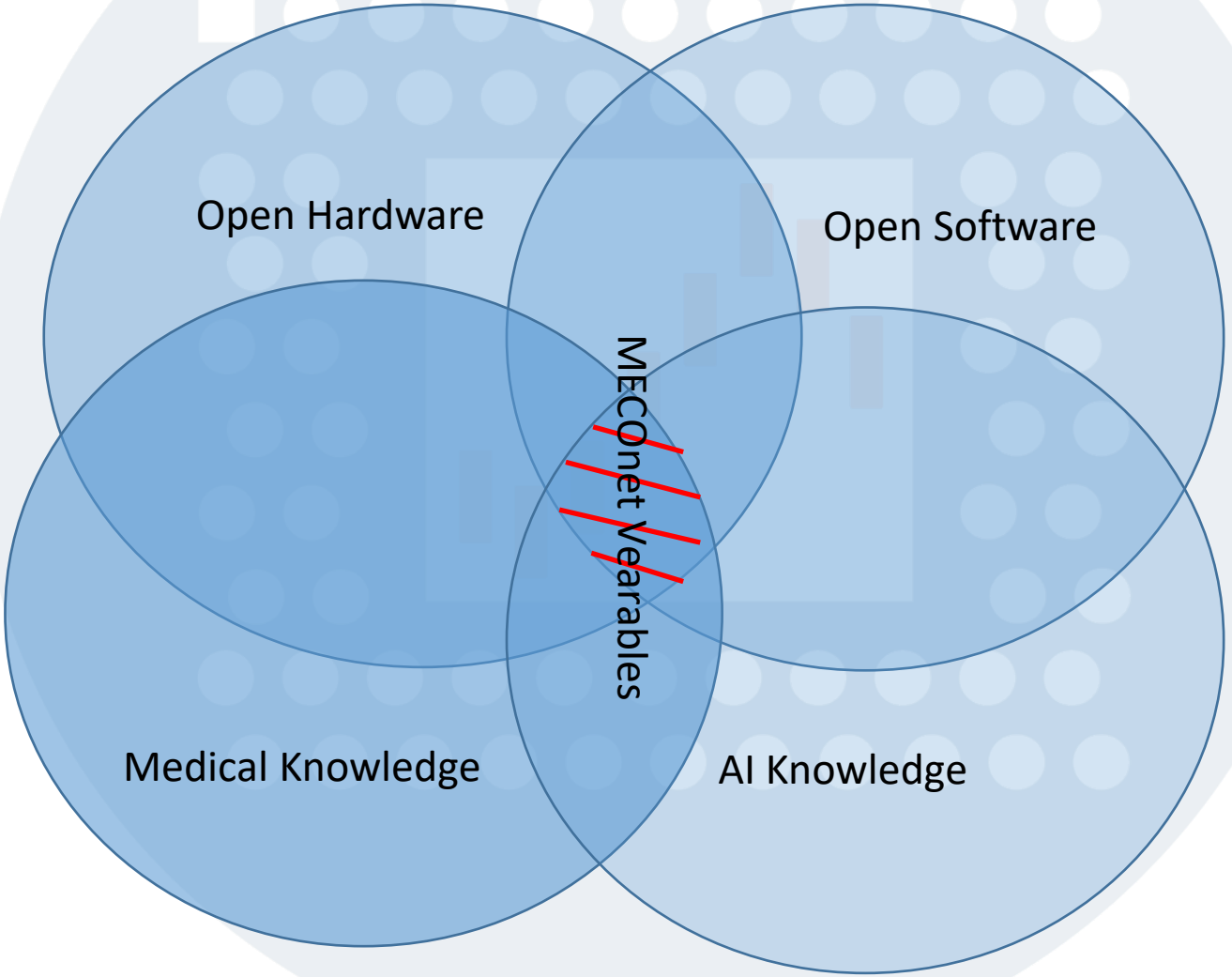
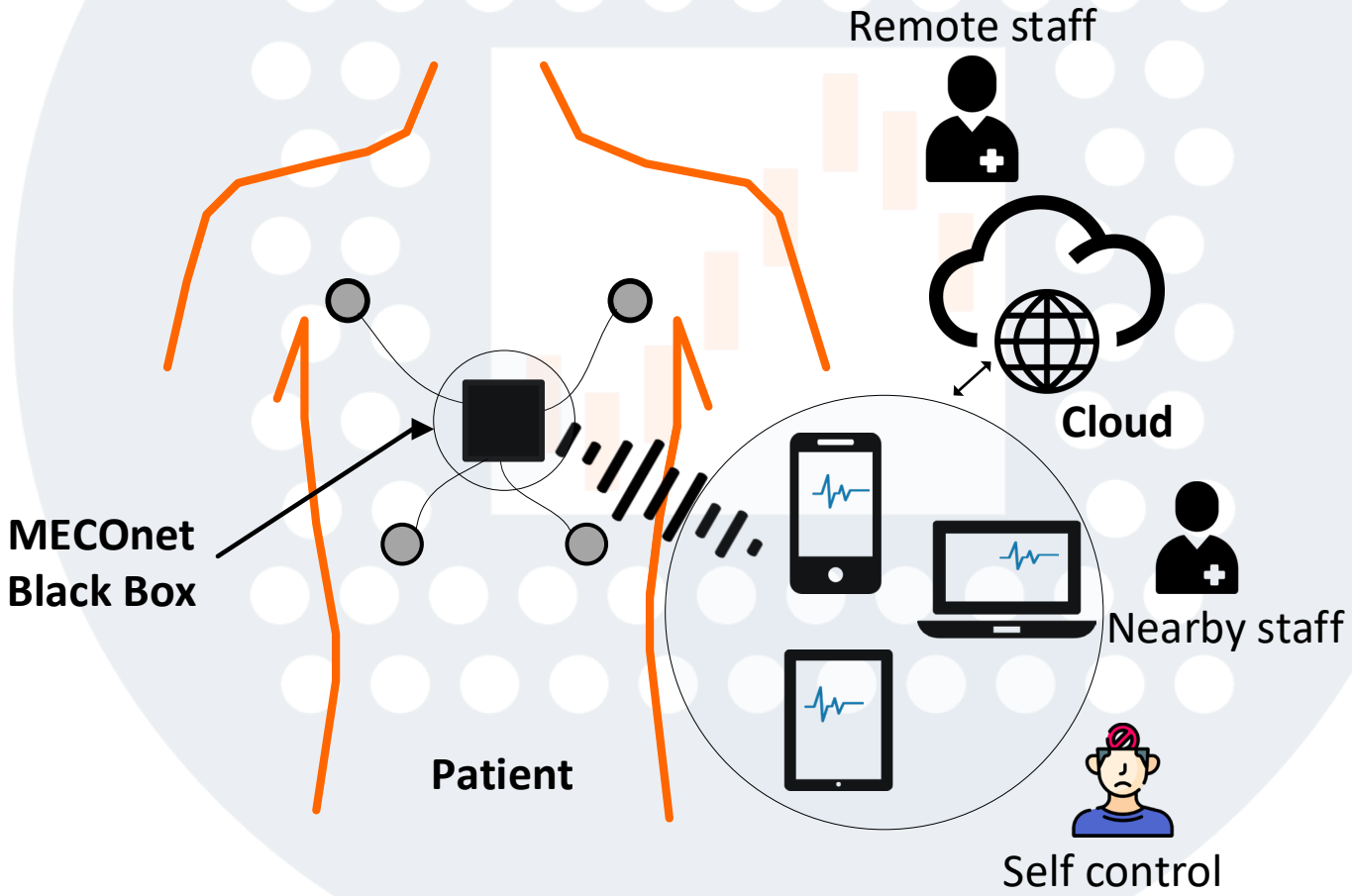
Content

- Main idea
- MECOnet approach
- Examples
- Conclusion

Main idea

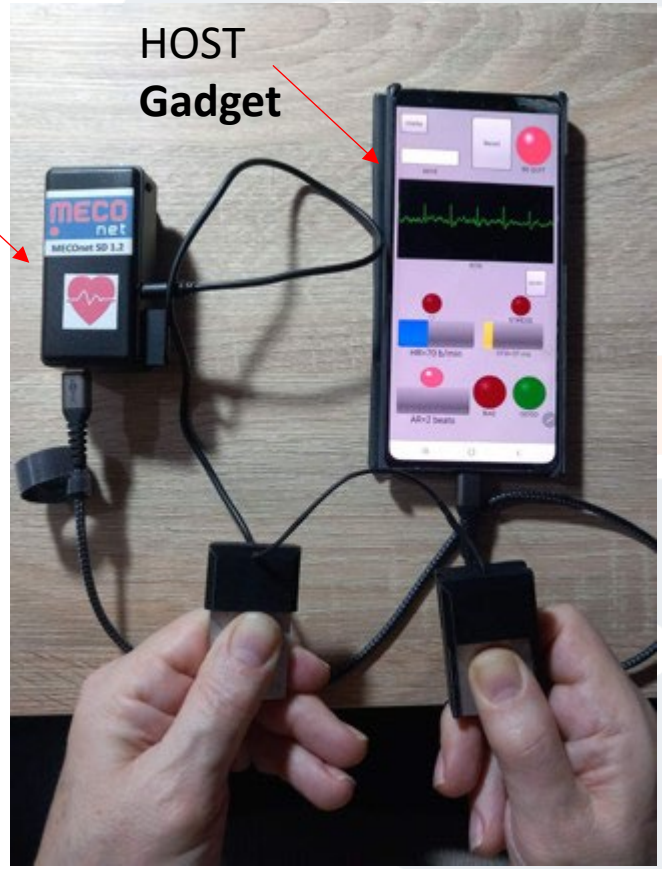

Open Hardware
Open Software
MECOnet Wearables
Medical Knowledge
AI Knowledge

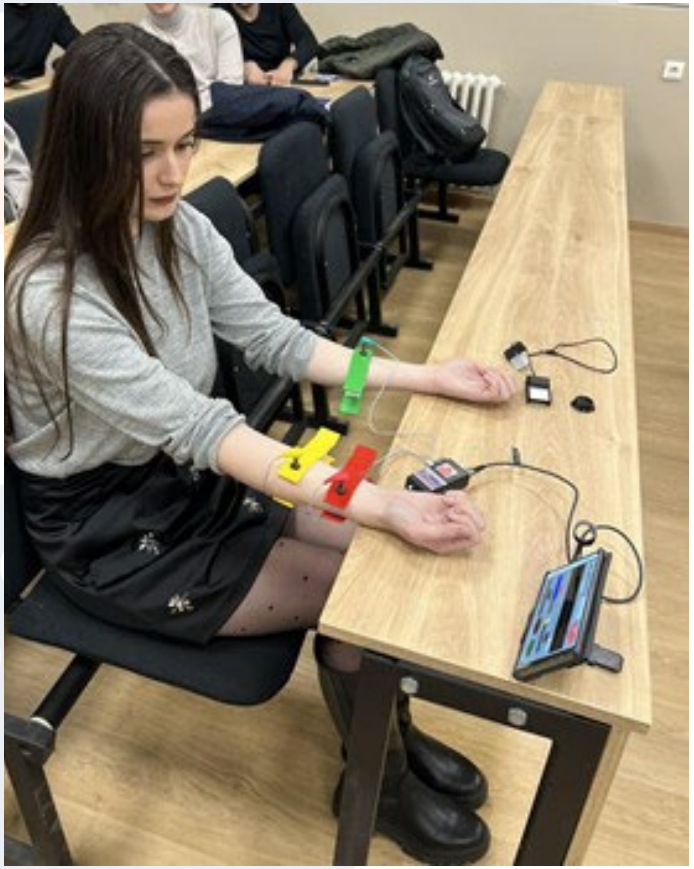
MECOnet Black Box Principle



Primjeri projektovanja...

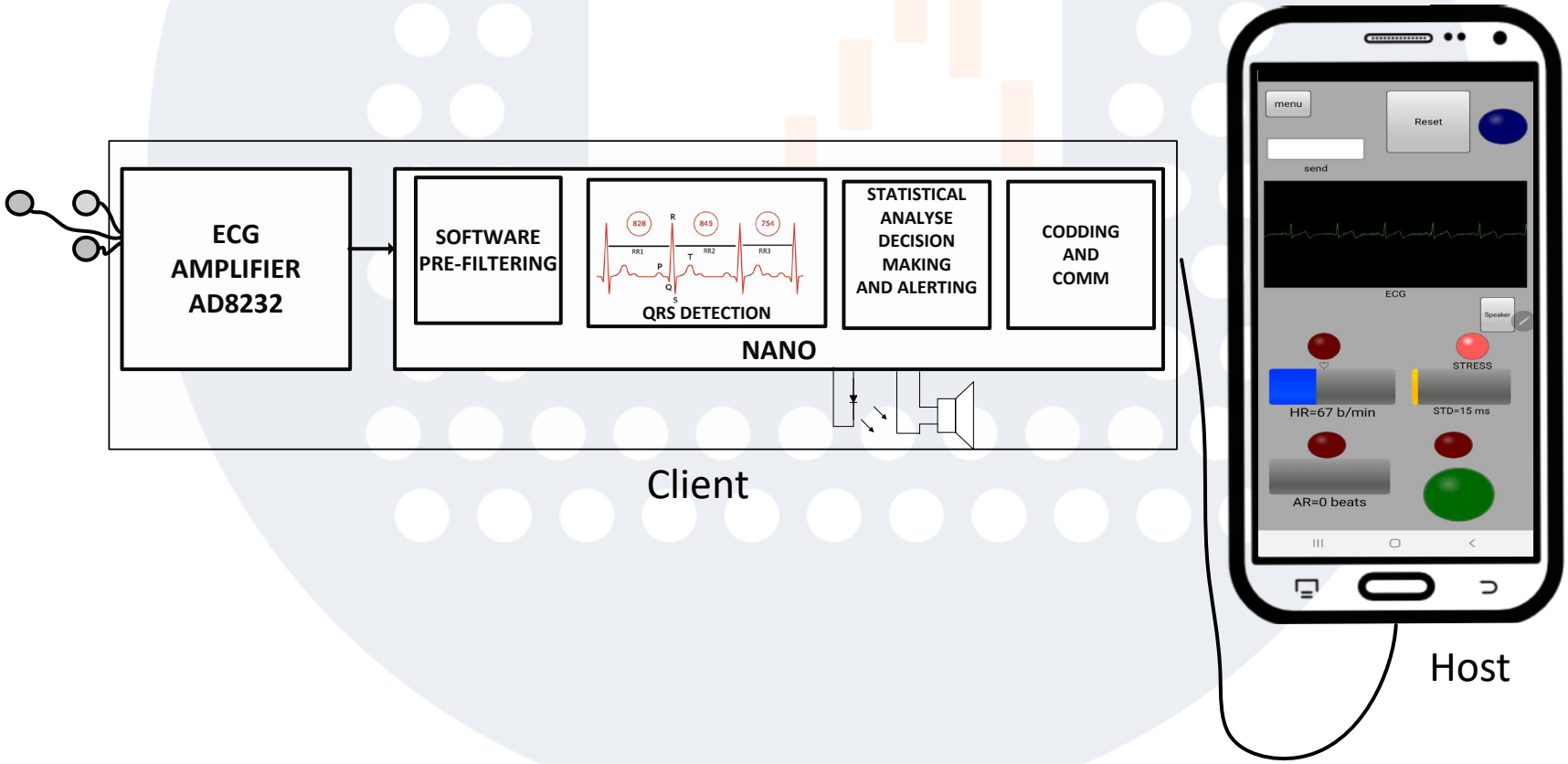
- Detektor-analizator srčanog ritma i stres detektor. Klient u obliku MECOnet blue box. GUI implementiran na platformi https://roboremo.app/ .





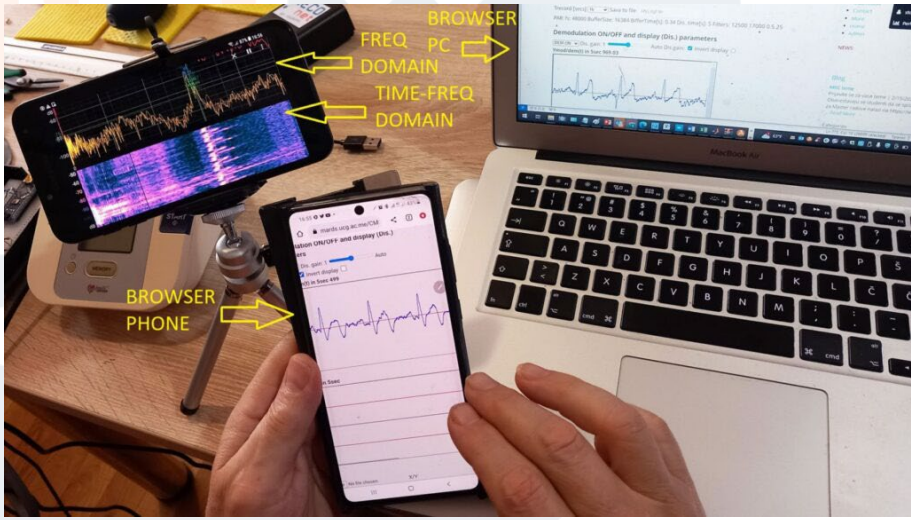
Primjeri projektovanja...

- Arhitektura klienta . Može raditi kao stand alone uredjaj ili povezan na gadget aplikaciju. Gadget aplikacija je puno konfornija i sadržajnija.



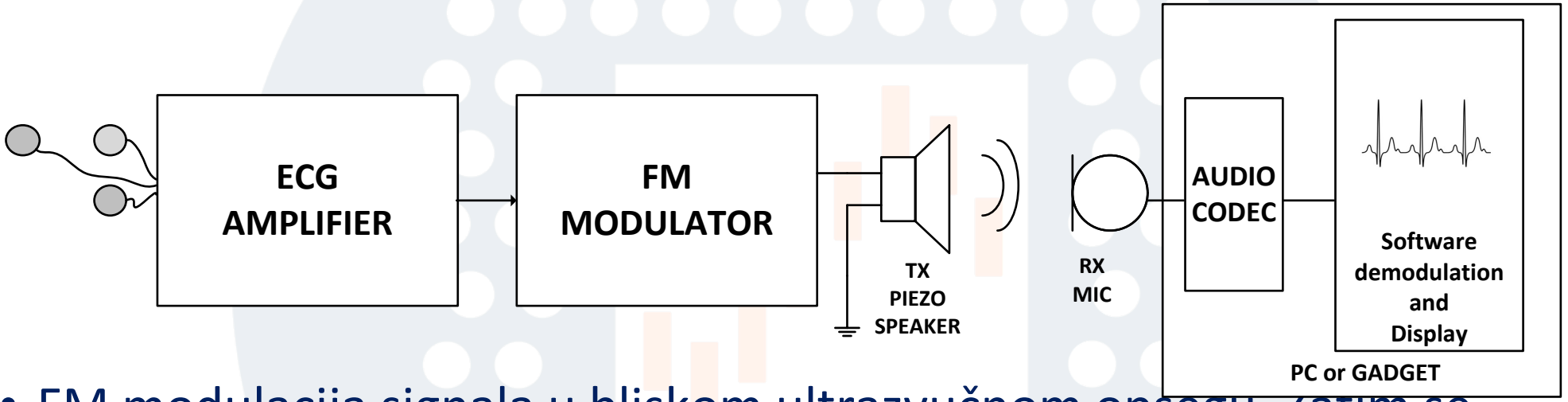
Primjeri projektovanja...

- “Whispering heart”. Prosti klient delegira većinu funkcija hostu more. Komunikacija se odvija u near ultrasound području.



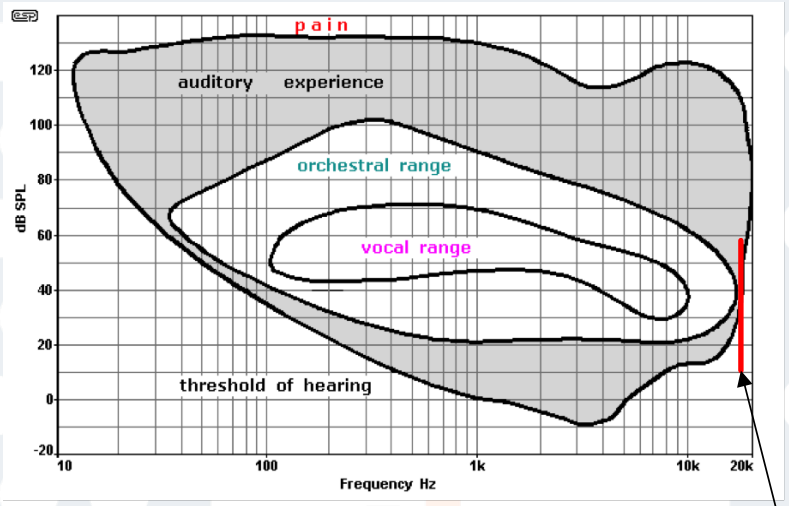
Primjeri projektovanja...

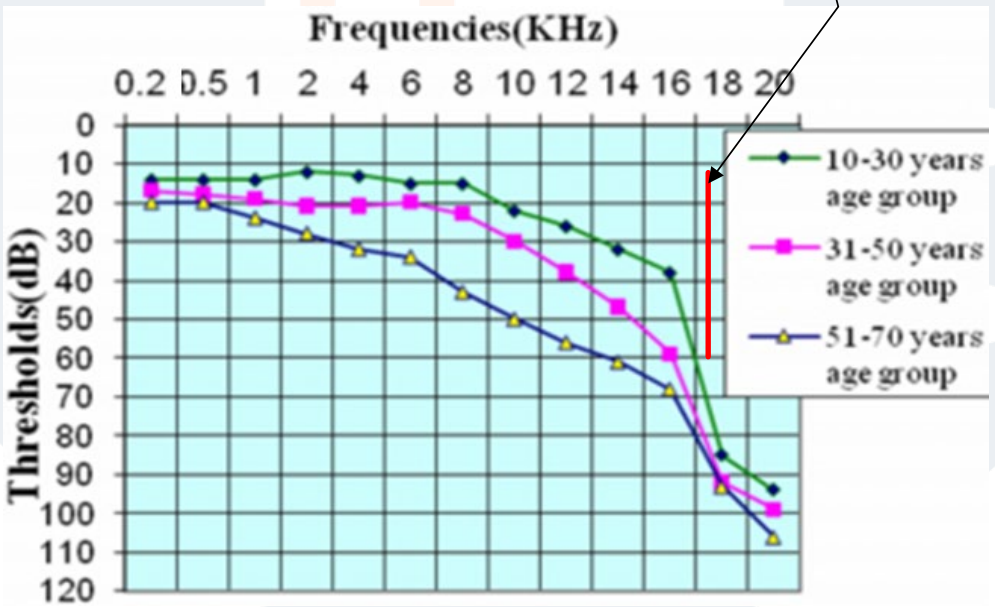
- “Whispering heart”. Arhitektura.



- FM modulacija signala u bliskom ultrazvučnom opsegu. Zatim se signal posmatra u vremenskom, frekvencijskom i vremensko-frekvencijskom domenu pomoću host softvera implementiranog u MATLAB-u ili JavaScript-u
- Različiti načini demodulacije uključujući Hilbertovu transformaciju i diskriminatorske tehnike.

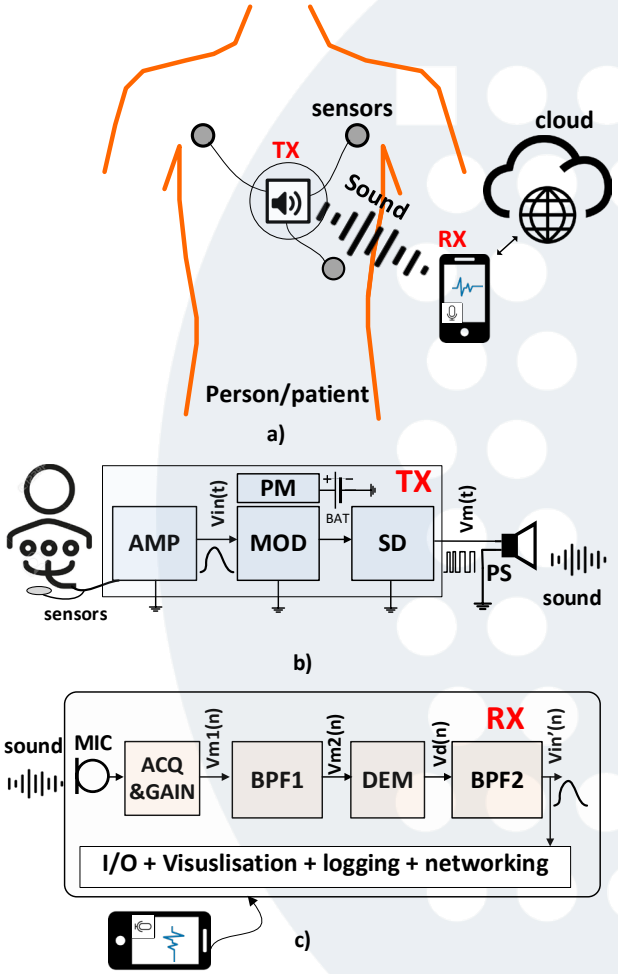
Methodology/Solution/PoC





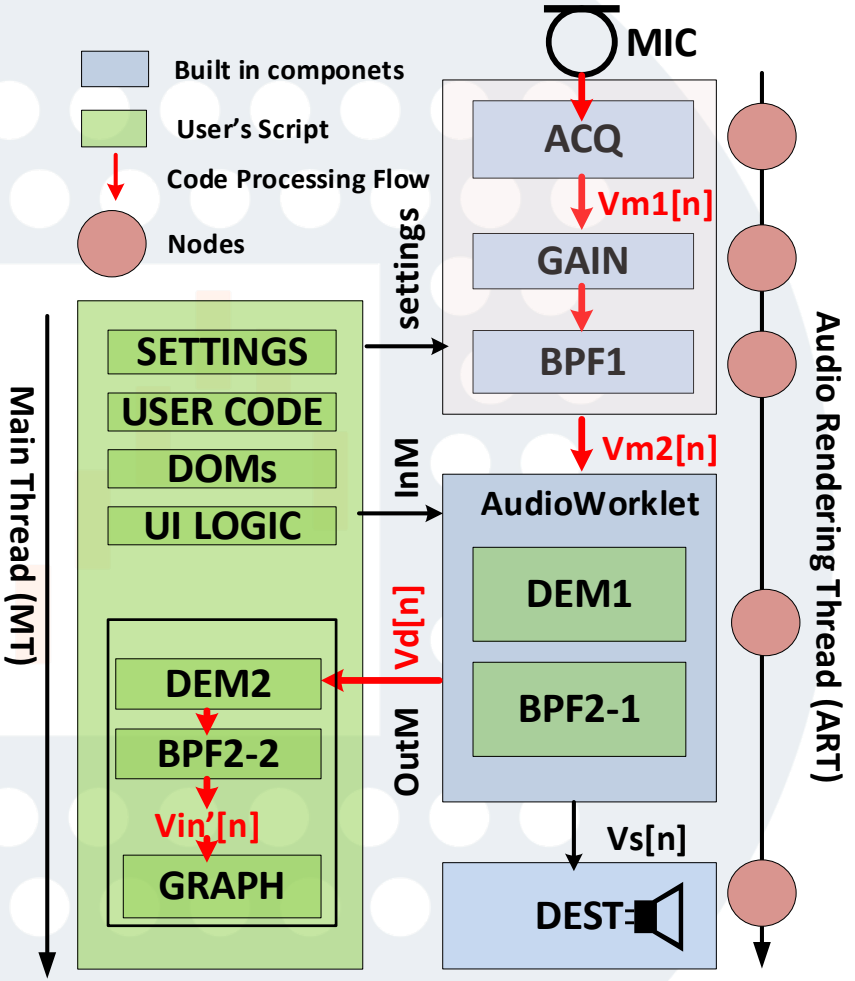
Selection of the working conditions.
In a range 16kHz:18kHz with adequate transmission power

PoC-1Ch



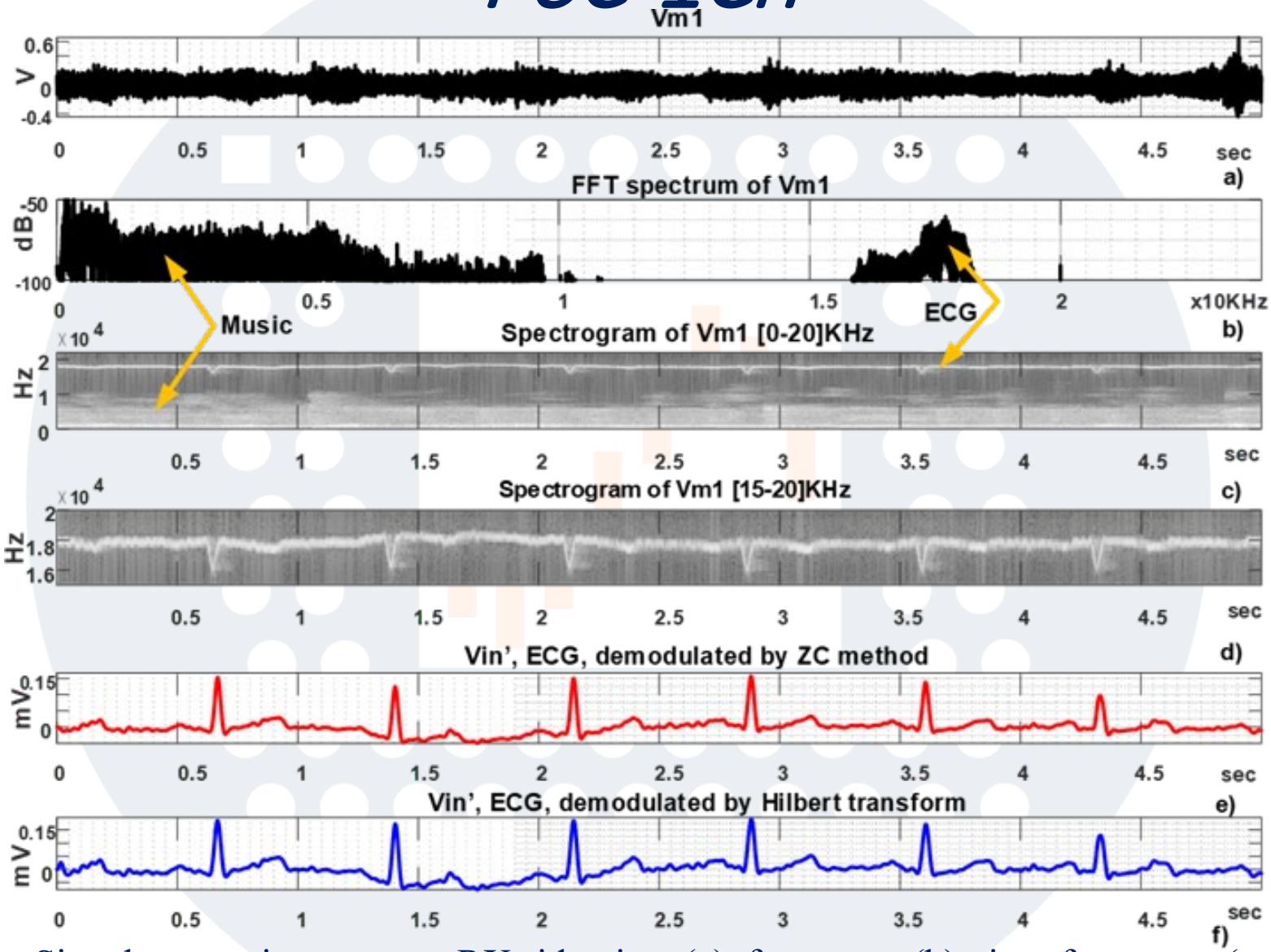
Architecture of 1Ch version

a) general b) electronics



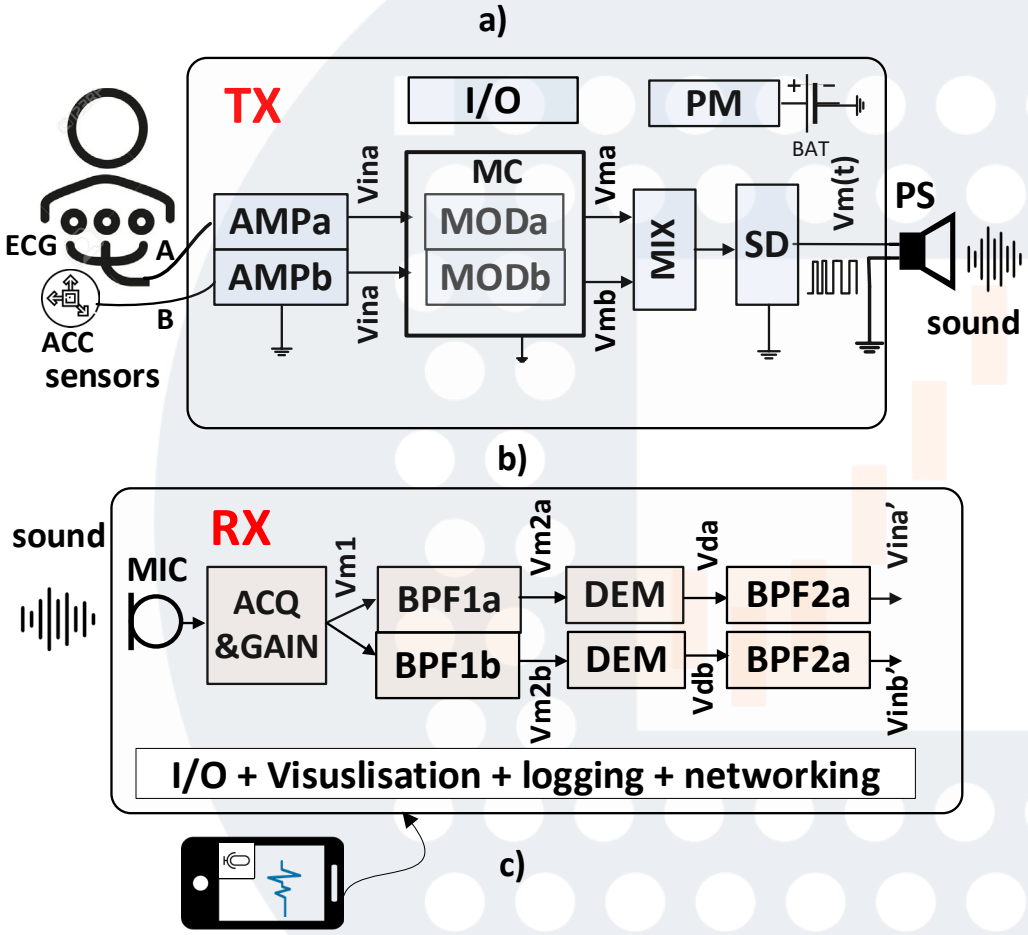
Software decoding architecture
(JavaScript+HTML+CSS+AudioAPI, 1Ch)

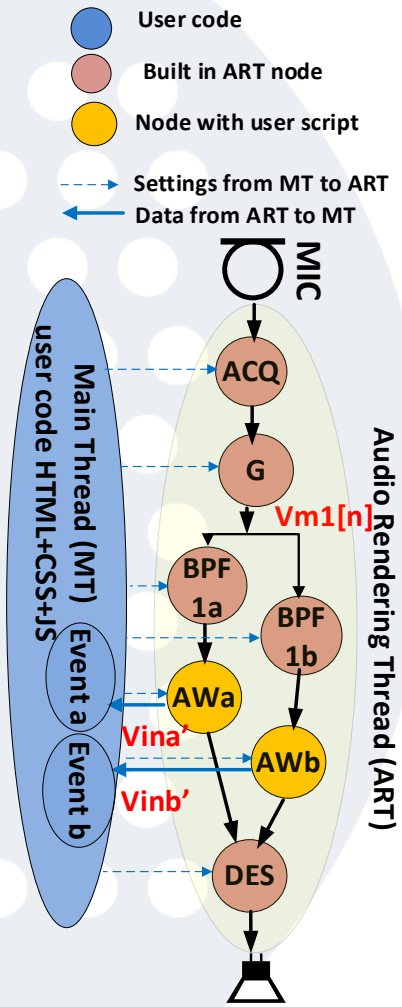
PoC-1Ch



Signal processing steps on RX side, time (a), frequency (b), time-frequency (c,d) domains and demodulation by ZC and Hilbert

PoC – 2Ch





Architecture of CW, 2CH version

a) general b) electronics

Software decoding architecture
(JavaScript+HTML+CSS+AudioAPI

PoC-2Ch

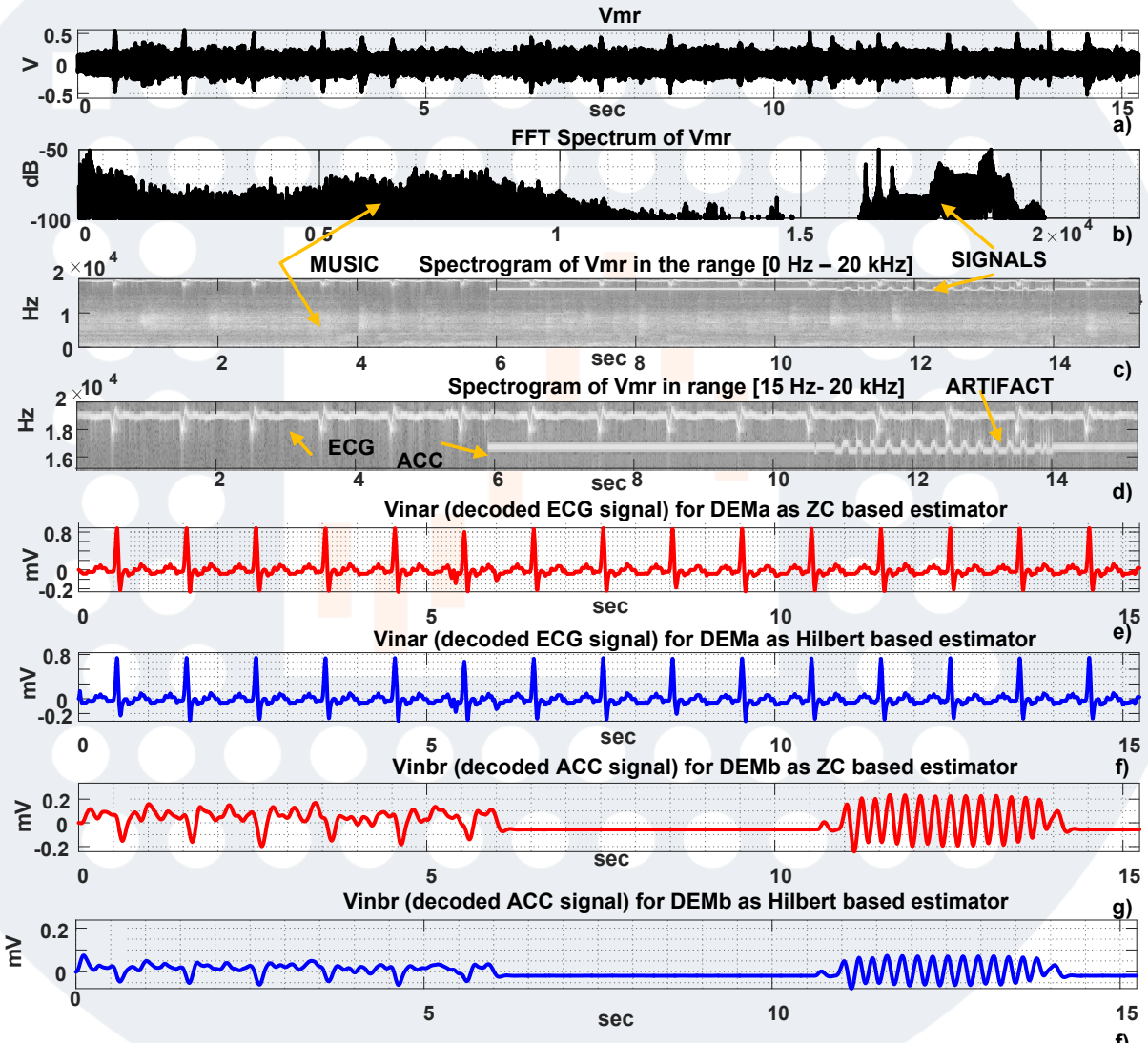


Illustration of the signal processing steps on RX side, implemented on real ECG and ACC signals.

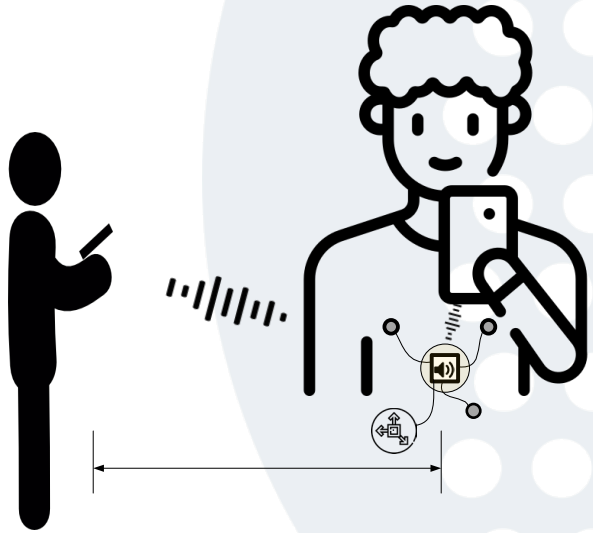
Testing & results

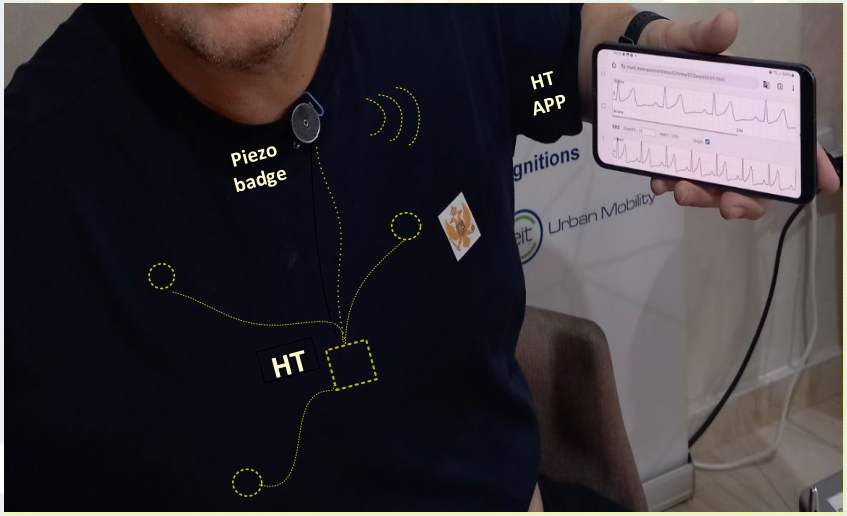
- Development environment

The experimental setup demonstrating the CardiaWhisper system. (1) The CardiaWhisper device acquires ECG signals using standard disposable Ag/AgCl electrodes and transmits data via sound. (2) A mobile phone displays the signal's spectral content for system verification. (3) Another phone runs custom JavaScript software for real-time demodulation and ECG visualization. (4) A desktop computer receives and analyzes the same signal simultaneously for development, testing, and debugging purposes.

Testing & results…

- Experiment environment



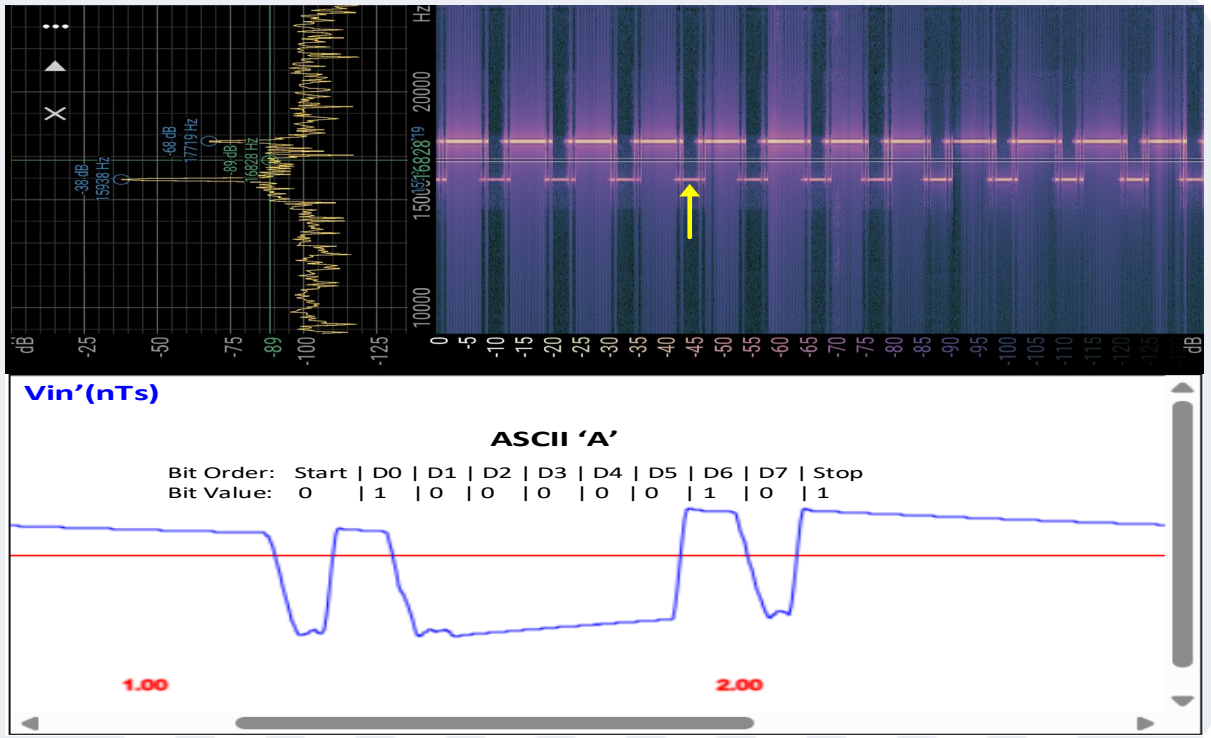


c)

Testing scenario a), system demo b), c) prototype

Testing & results…

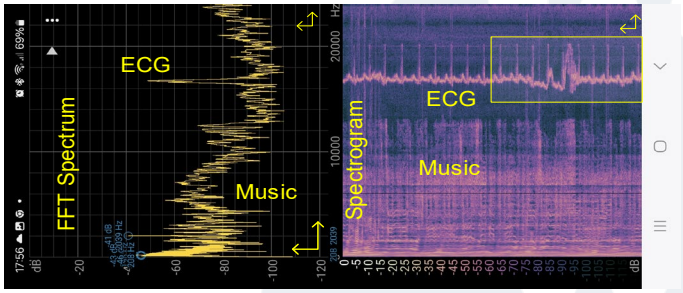
- Functionality testing, the simplest case, sending only alarm



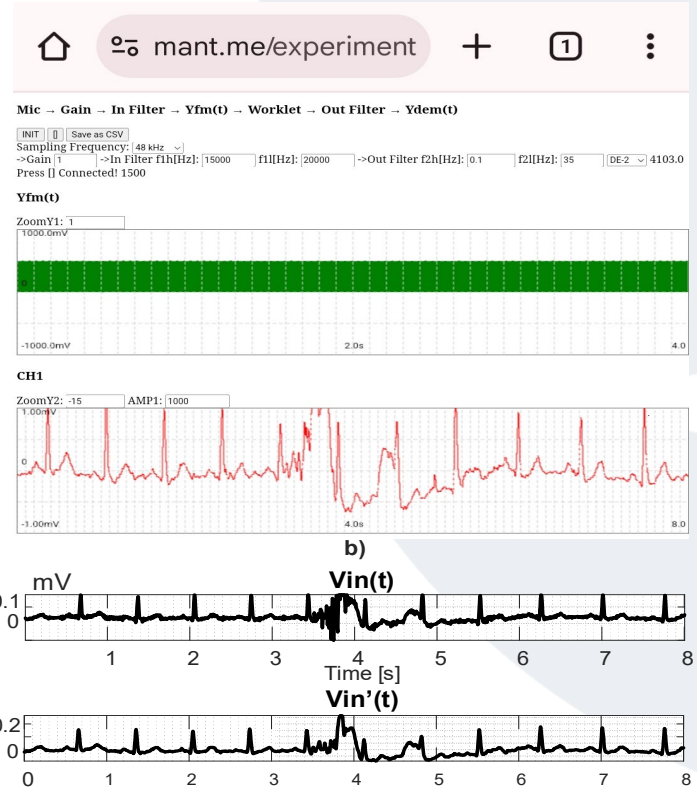
"A" – Alarm, sent over sound

Testing & results...

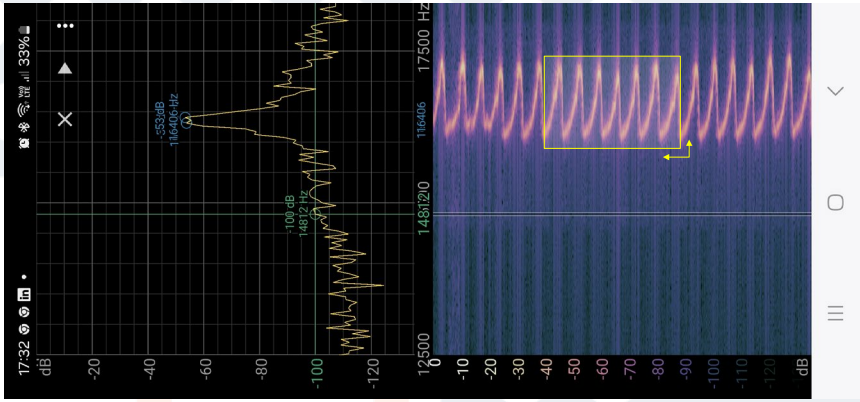
- Functionality testing, Vital signs, 1Ch Version, ECG or PPG



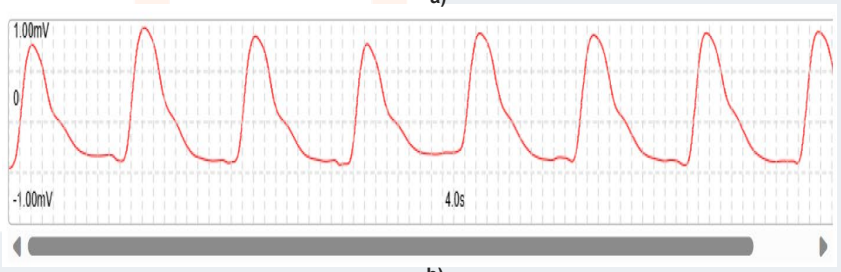
a)



b)



a)



b)

Time, frequency and time-frequency domains are considered, left ECG case, right PPG

a) FFT and STFT spectrums,
b) demodulated signal by HT APP,
c) up original ECG signal on the input of transmitter,
d) down reconstructed ECG signal on the output of receiver.

Testing & results...

- Functionality testing, Vital signs, 2Ch Version, ECG and PPG

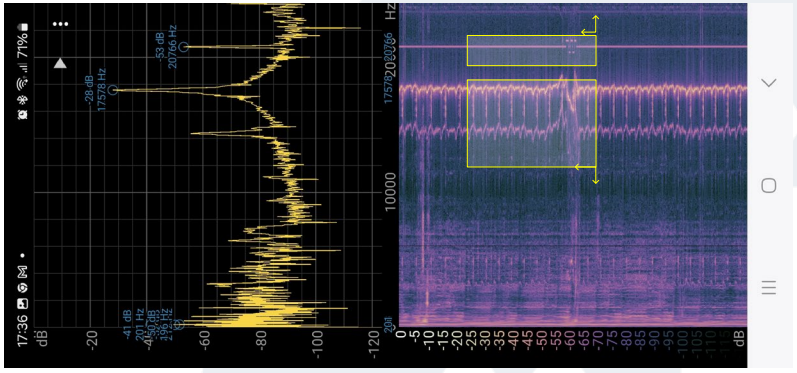
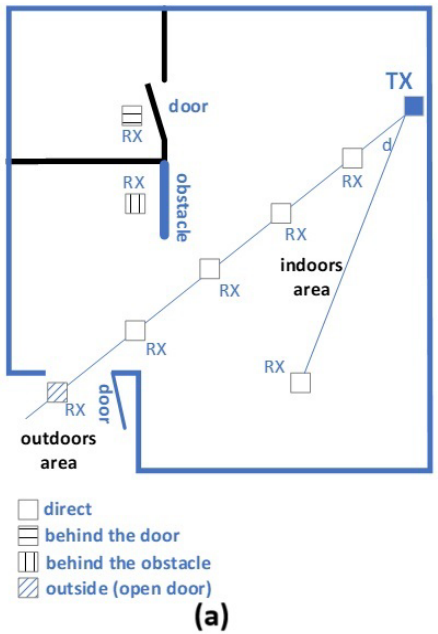


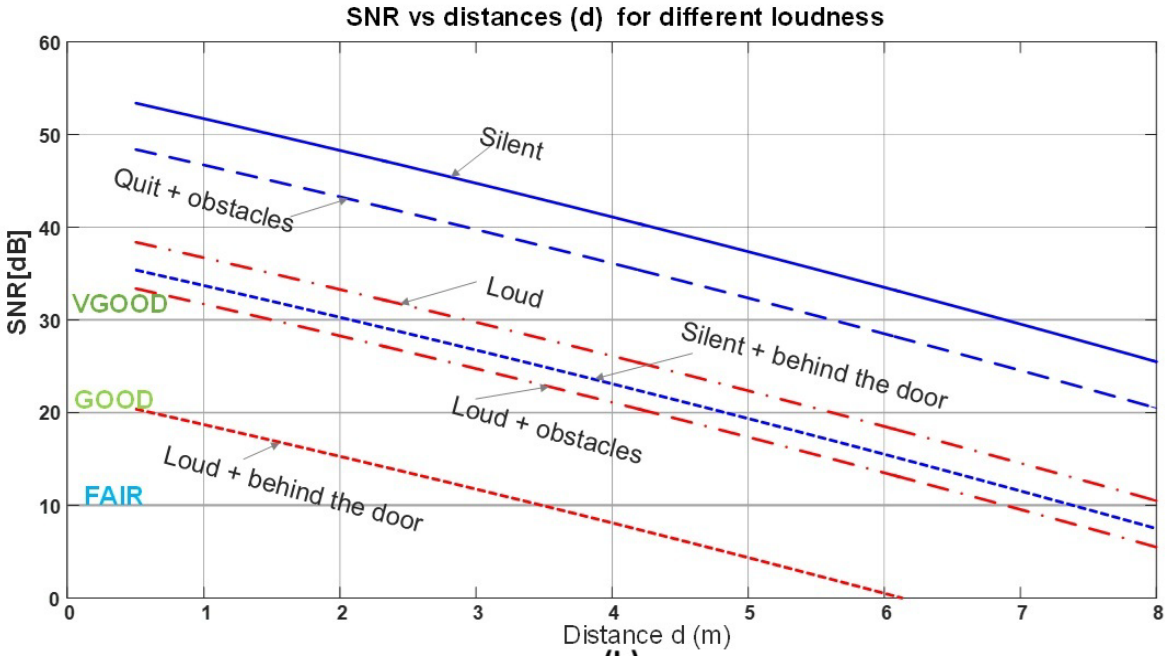
Illustration of FFT and STFT spectra of ECG and ACC signals in Spectroid APK. b) Demodulation and visualization of ECG and ACC signals directly in HT JavaScript+HTML+CSS APK.

Testing & results

- *SNR and range*



(a)

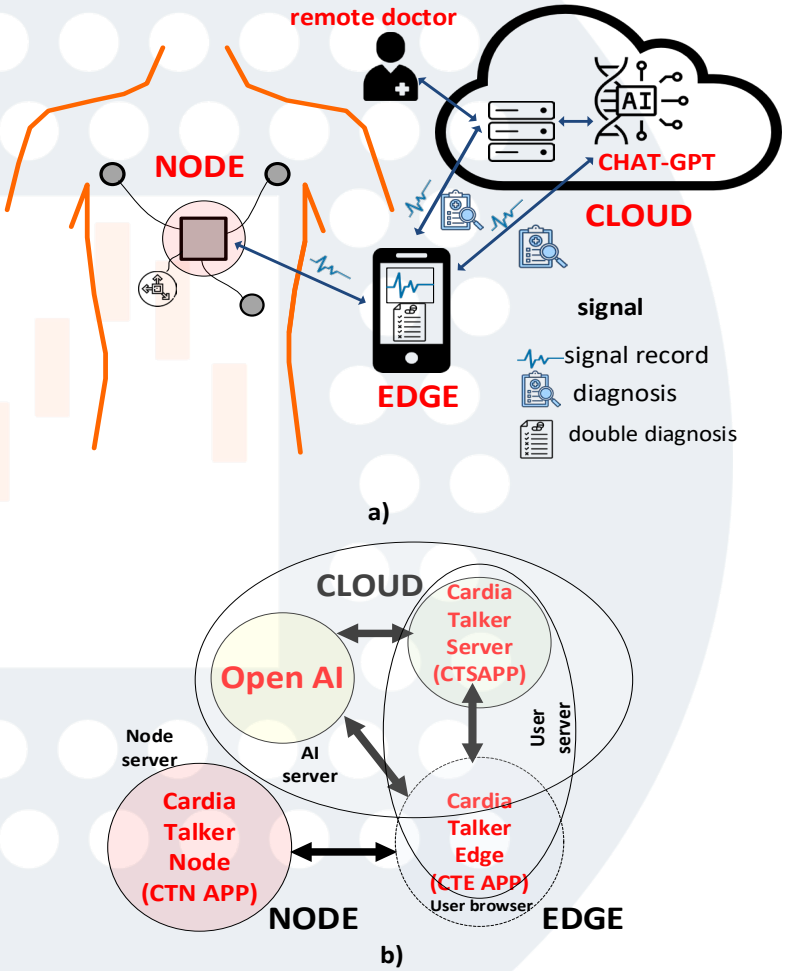


(b)

The floor plan and measurement scenario: The transmitter (TX) is placed indoors, while receivers (RX) are positioned at various locations—direct line of sight, behind obstacles, behind a door, and outdoors (with an open door). (**b**) The signal-to-noise ratio (SNR) as a function of distance d for different environmental loudness conditions and receiver positions. Scenarios shows the measured SNR as a function of distance for different scenarios. The accepted thresholds for signal quality were defined as follows: VERY GOOD (SNR ≥ 30 dB), GOOD (20 dB < SNR < 30 dB), and FAIR (10 dB < SNR < 20 dB). As can be observed, even under “Loud + obstacles” conditions, VERY GOOD signal quality (SNR ≥ 30 dB) is achieved within a radius of d = 1.5 m from the TX, and GOOD quality is maintained up to d = 4.2 m. These results demonstrate the robustness of the system in real-world indoor environments.

CardiaTalker- ChatGPT

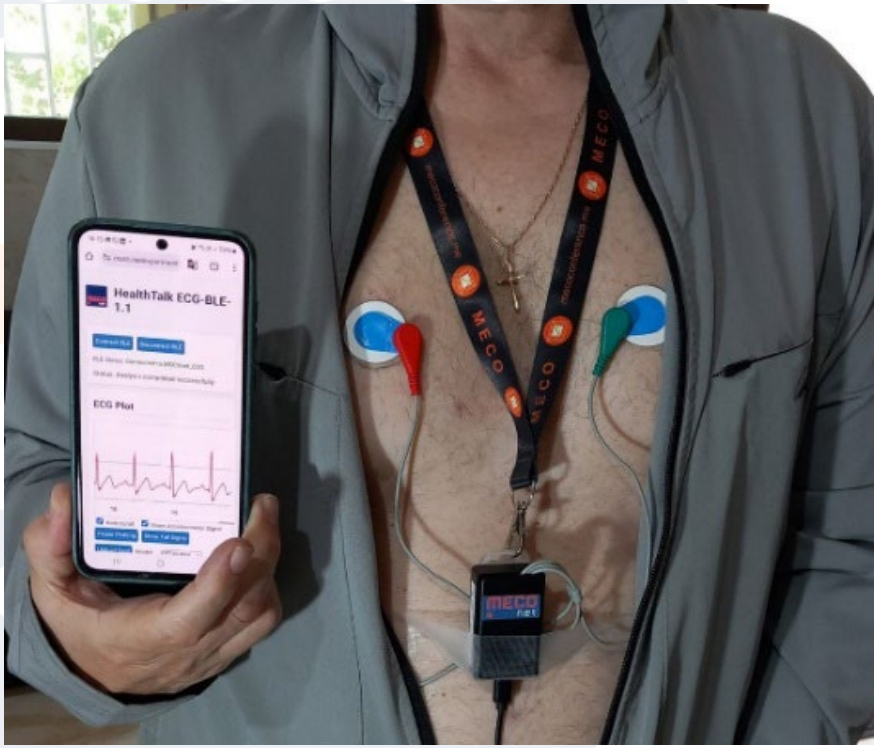
- Feasible AI supported system for cardia disorders monitoring
- With current state of the art in IoT and AI can be easy implemented.
- MECOnet developed CardiaTalker concept



The system architecture of CardiaTalker, a) overall system components, b) application layer architecture.

Methodology

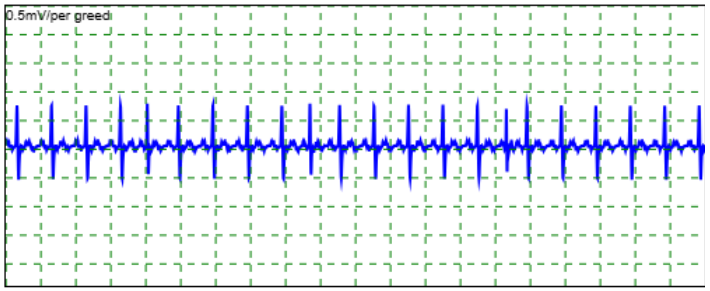
- CardiaTalker is attached to the patient's body, records the ECG signal and communicates with the mobile phone application and further to the cloud.
- Provide double diagnosis from ChatGPT and remote doctor.
- Has hardware and 3 layers software, firmware, Edge, Cloud



CardiaTalker- ChatGPT

Parameter	Specification / Result
Microcontroller Unit (MCU)	ESP32 (dual-core, Wi-Fi + BLE, low-power operation)
ECG Module	AD8232 (analog front-end for biopotential measurement)
Accelerometer (ACC)	Integrated DXL335 3-axis accelerometer
Power Source	5000 mAh Li-ion power bank
Battery Life	>60 hours of continuous operation
ADC Resolution / Sampling Rate	12-bit resolution, 200 Hz sampling frequency
Average Power Consumption	~75 mA
Edge Communication Protocol	BLE (Bluetooth Low Energy)
Cloud Communication Protocol	Wi-Fi (HTTP POST to REST API)
Edge Communication Range	~10 meters indoor with >98% packet reception rate
Cloud Upload Time (30s ECG)	~2 seconds from CET App to CST App
OpenAI Response Time (60s ECG, gpt-4o-mini model)	~40 seconds (includes upload, processing, and return)
OpenAI Response Time (60s ECG, gpt-4-turbo)	~19 seconds (includes upload, processing, and return)

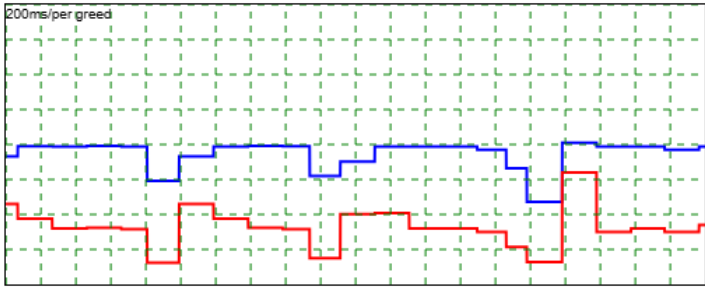
Poincare



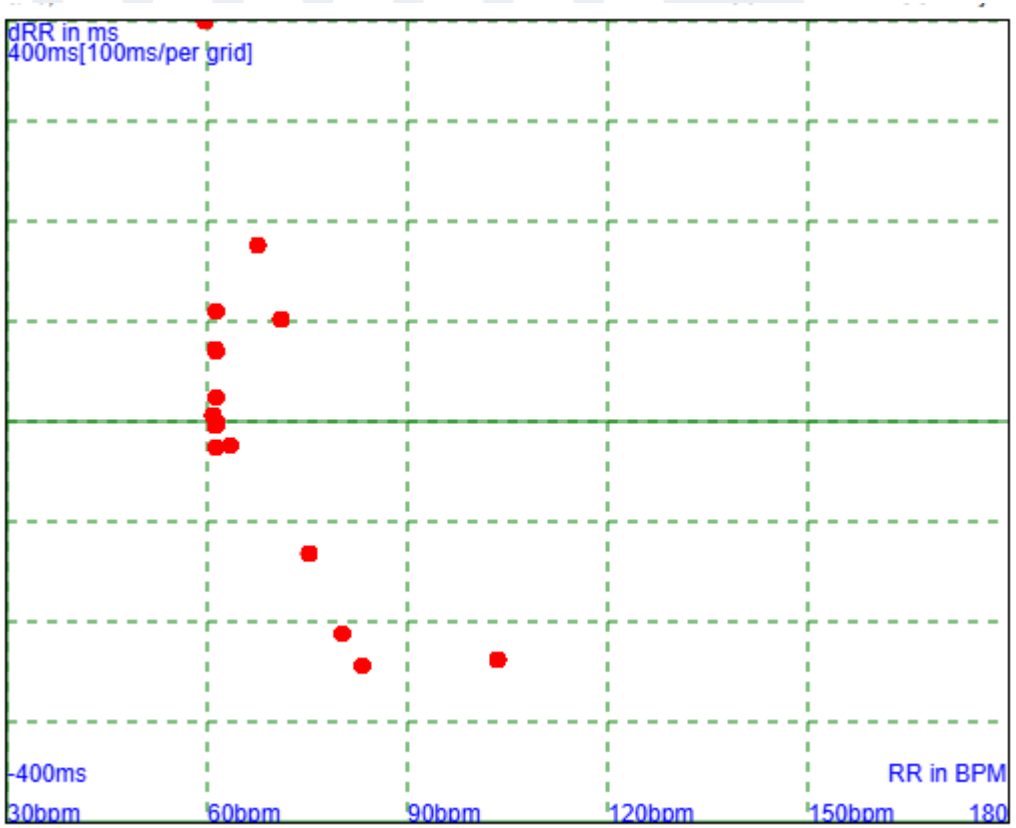
RR, dRR(t)

MAX/MIN RR[ms]: 1012 591 MAX/MIN dRR[ms]: 400 -245

HRav[beats/pmin]: 64 STD_RR [ms]: 106

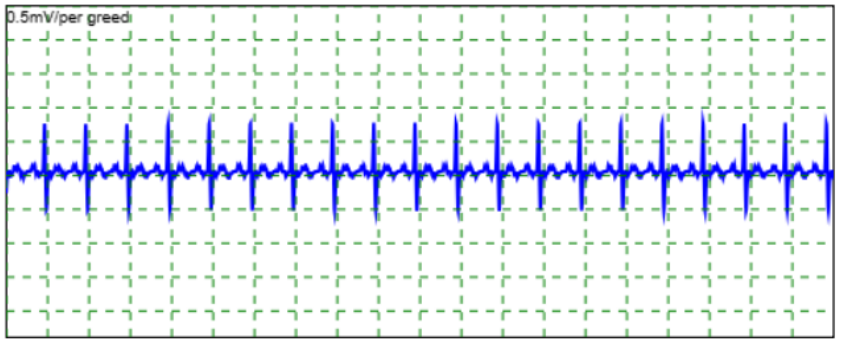


Poincaré plot dRR(t)=f(RR(t))



Poincare

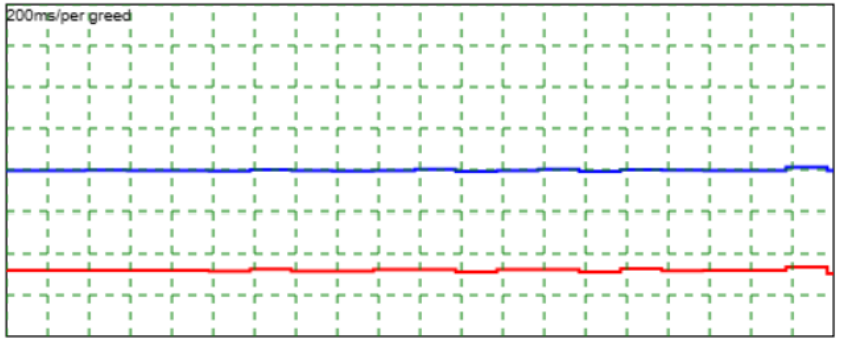
ECG(t)

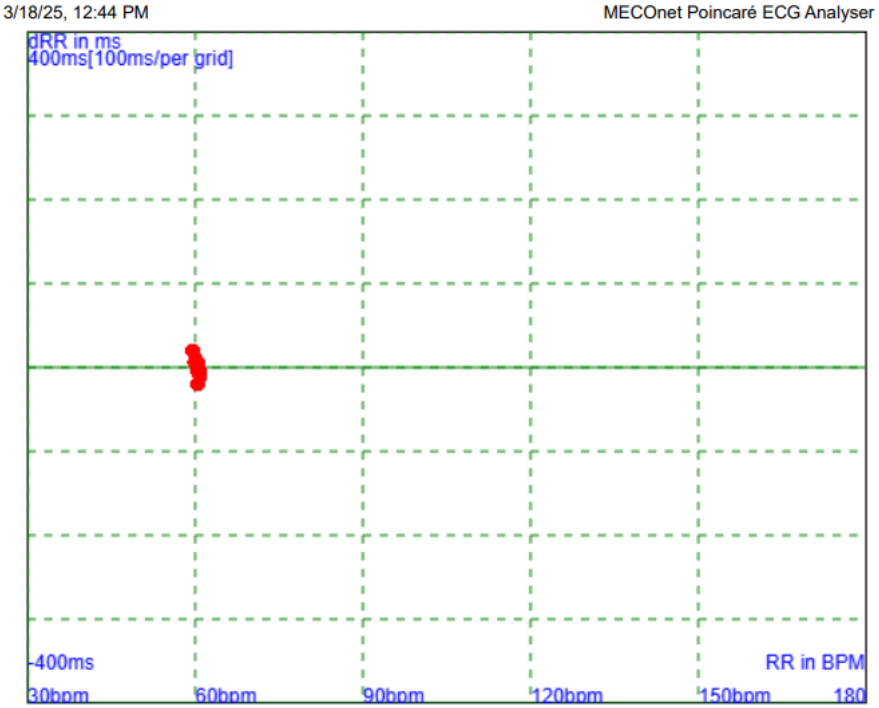


RR, dRR(t)

MAX/MIN RR[ms]: 1016 991 MAX/MIN dRR[ms]: 20 -20

HRav[beats/pmin]: 60 STD_RR [ms]: 5





Conclusions

- It is possible by using MECOnet Creative integration to design very sophisticated and helpful instrument.
- The Examples are presented
- Main part of presentations are results of the project HealthTalk

ACKNOWLEDGMENT

HealthTalk Project is supported by
Innovation Fund of Montenegro
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for whose support the authors are very grateful

Fond
za inovacije
Crne Gore

Thank you, Q&A?