PERSONAL ELECTROMYOGRAPHIC BIOFEEDBACK SYSTEM „MYMYO“

Una Pale[1], Mario Cifrek[1], Igor Krois[1], Stanislav Peharec[2]

1 University of Zagreb, Faculty of Electrical Engineering and Computing, Croatia

2 Polyclinic Peharec, Pula, Croatia

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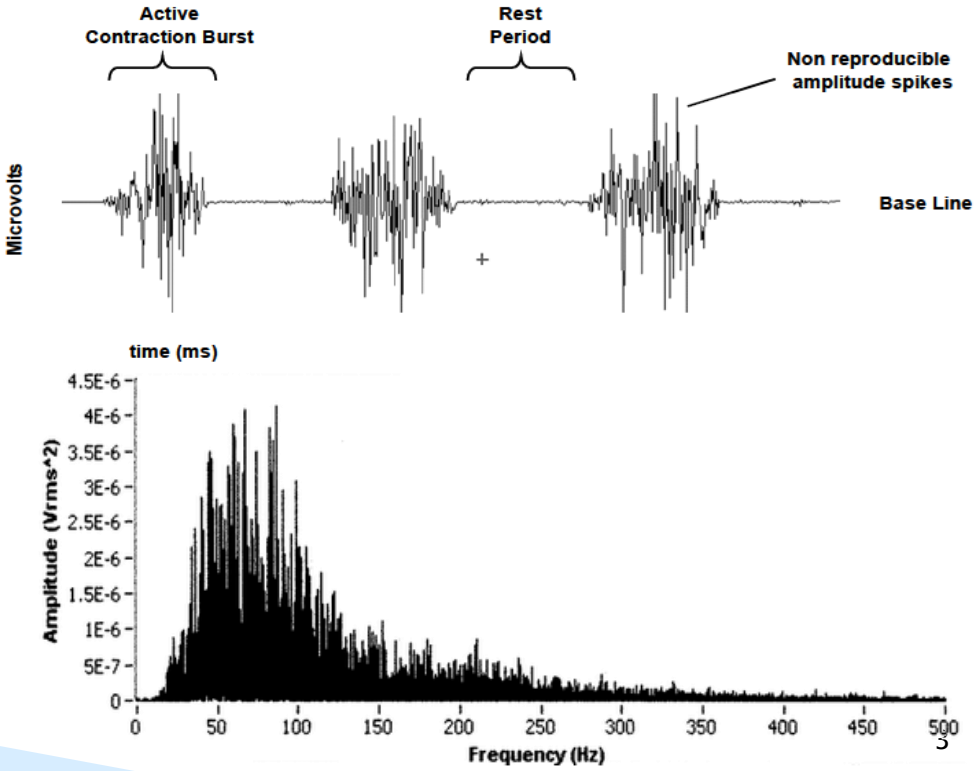
Electromyography

- Electromyography
  - development, recording and analysis of myoelectric signals
  - kinesiological EMG
    - muscles activation as response to movements

- Myoelectric signals
  - superposition of motor unit action potentials (MUAPs)
    - random shape
  - raw surface EMG
    - amplitude: few µV to 2-3 mV
    - frequency spectrum :
      10 to 500 Hz
      peak between 20 and 150 Hz



Motivation and idea

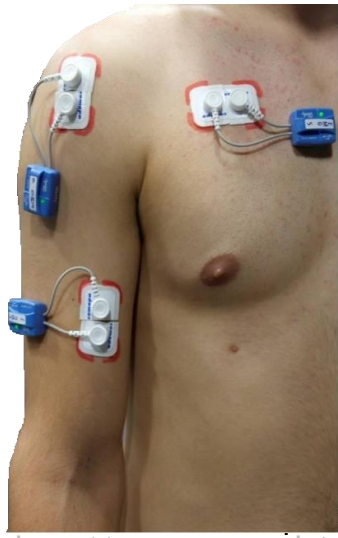
TYPICAL

- Typical EMG measurement system
  - central unit
    with more EMG channels
    wire connected
  - common reference electrode
  - specially designed device with GUI
- Drawbacks
  - Expensive
  - Complex to use

OUR

- To design, construct and test
  - single- channel
  - compact-size
  - wireless
  - surface EMG acquisition system
- Each channel is independent acquisition system
- smart phone as GUI
  - cheap
  - various applications
    - physiotherapy application

http://www.lahsit-schlaganfall-reha.de/en/hand-arm-rehabilitation.html



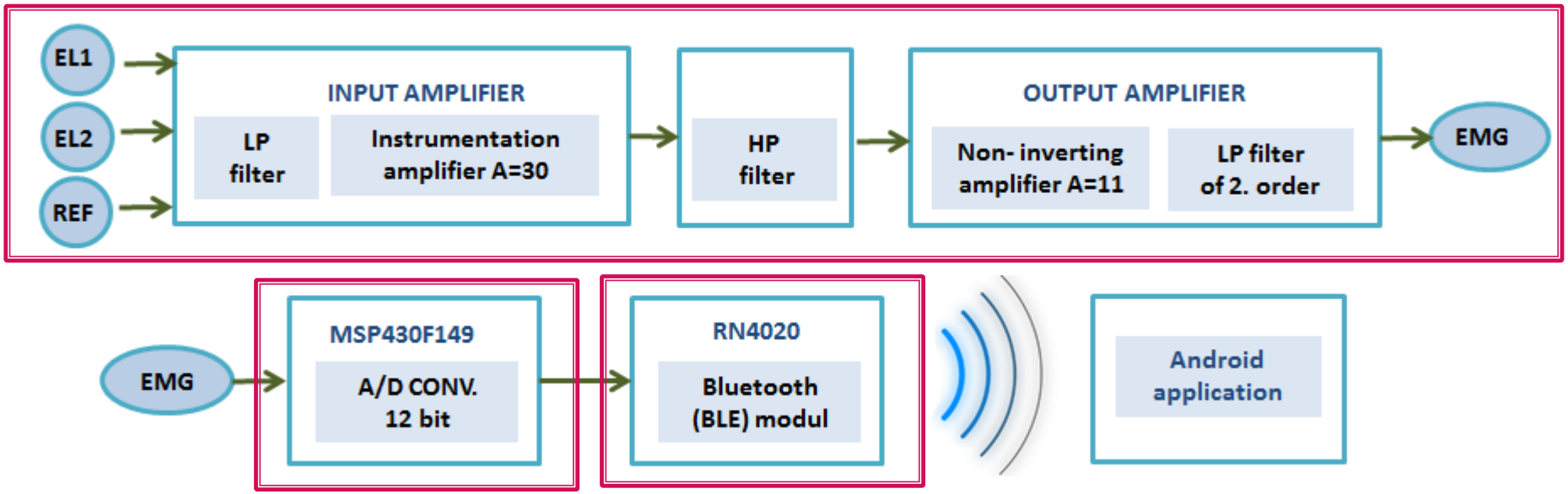
http://www.myon.ch/

Requirements

- Signal of interest
  is very small [µV, mV]
  - CMRR as high as possible >95dB
  - impedance of the input amplifier at least 10 times
    the given impedance
    of the electrodes
  - 12 bit ADC needed
- Bandpass [10-500]Hz
  - sampling rate >1kHz

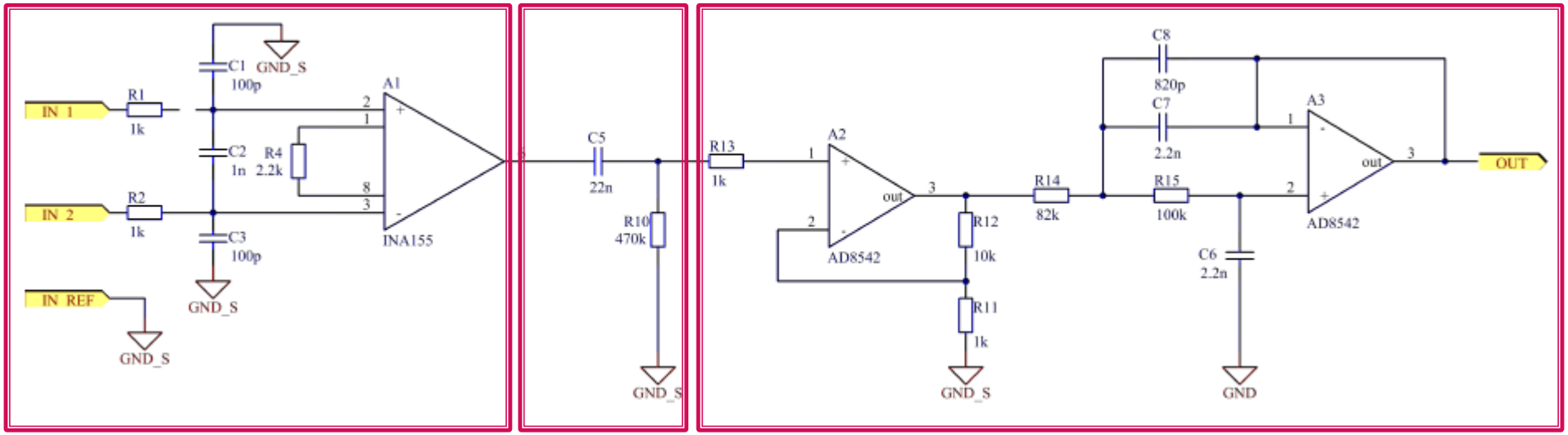
- Electrodes
  - stable electrode contact and low skin impedance
  - simple skin preparation
  - physical requirements
    - diameter ~1cm, distance ~2cm
    - parallel to muscle
  - reference electrode
- Bluetooth low energy
  - small power consumption
  - smart phone as GUI

Hardware



- 3 hardware parts to design and construct:
  - analog signal processing part
  - microcontroller
  - bluetooth module

Analog signal processing



- Input low pass filter
  (RF frequencies)
  - $f_{g\_comm} = 1.6MHz$ and $f_{g\_diff} = 0.16MHz$
- Instrumentational amplifier
  - gain 30, CMRR 100dB
- Notch filter not used

- High pass filter
  - electrode movements, changes of electrode skin impedance..
  - $f_g \approx 15Hz$
- Output amplifier
  - non-inverting amplifier with gain 11
  - low pass Bessel filter
    - antialiasing filter
    - $f_g \approx 500Hz$
    - constant group delay

Power supply circuitry

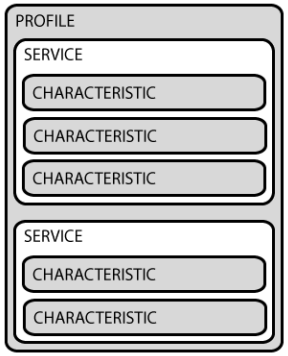
- Input voltage range [3.0, 5.5]V
  - LiPo battery, USB …
- LiPo battery - 500mAh
- LiPo battery charger

Microcontroller

- MSP430F149
  - ultra-low-power microcontroller
    - supply voltage [1.8,3.6]V
    - 280 µA power consumption in active mode
  - integrated 12-bit A/D converter
  - recommended for biomedical applications

Bluetooth module

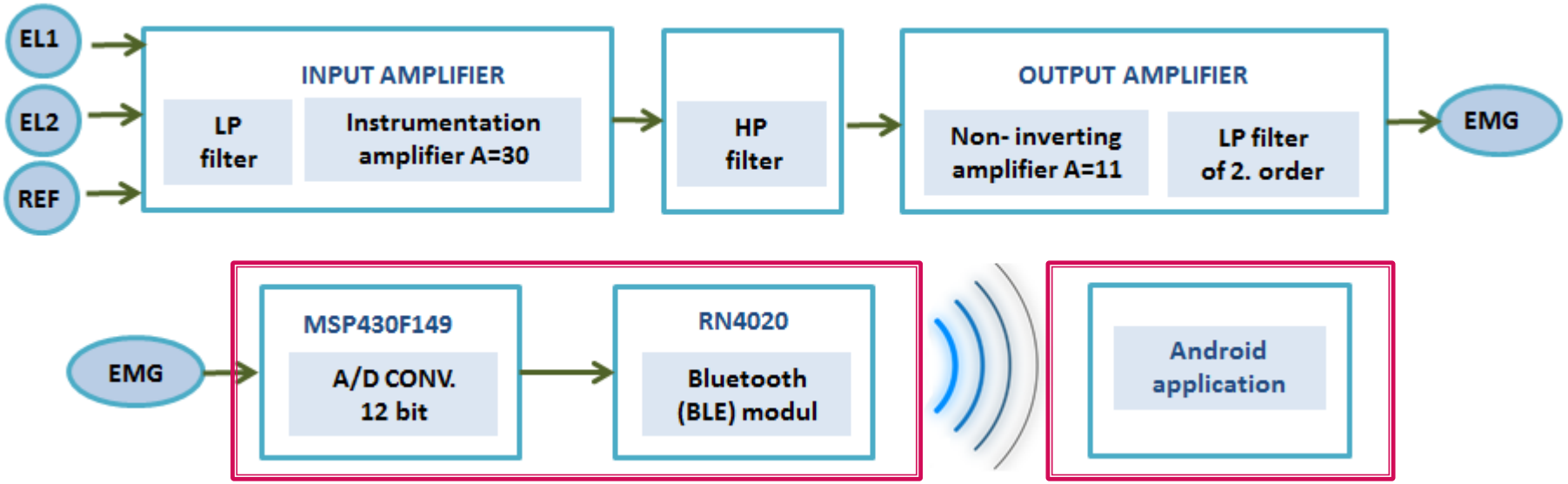
- Bluetooth low energy (BLE)
  - reduced power consumption
  - typical operating range [2,5]m
  - specific protocol structure
    - Profiles, Services, Characteristics
- RN4020 (Microchip)
  - MLDP profile – Microchip Low-Energy Data Profile
    - every data from UART sent wirelessly to the peer device



Data throughput

- **EMG requirements**
  - $1kHz$ sampling rate - $12bits \; -> \; 2bytes$
  - $16kbit/s$ + auxiliary bits in packets -> $\sim 18kbit/s$
- **BLE possibilities**
  - low power consumption - connection events
    - every 7.5 ms, minimum
  - packets of $20 \; bytes$
  - PPCE – packet per connection event
    - depends on BLE chip (7 max) and smart phone (2-3 max)
    - smart phone – $133Hz * 3 * 20byte \approx 64kbit/s$
  - Microchip
    - MLDP_v2 (Notification) – $56kbit/s$ (two RN4020 peers)

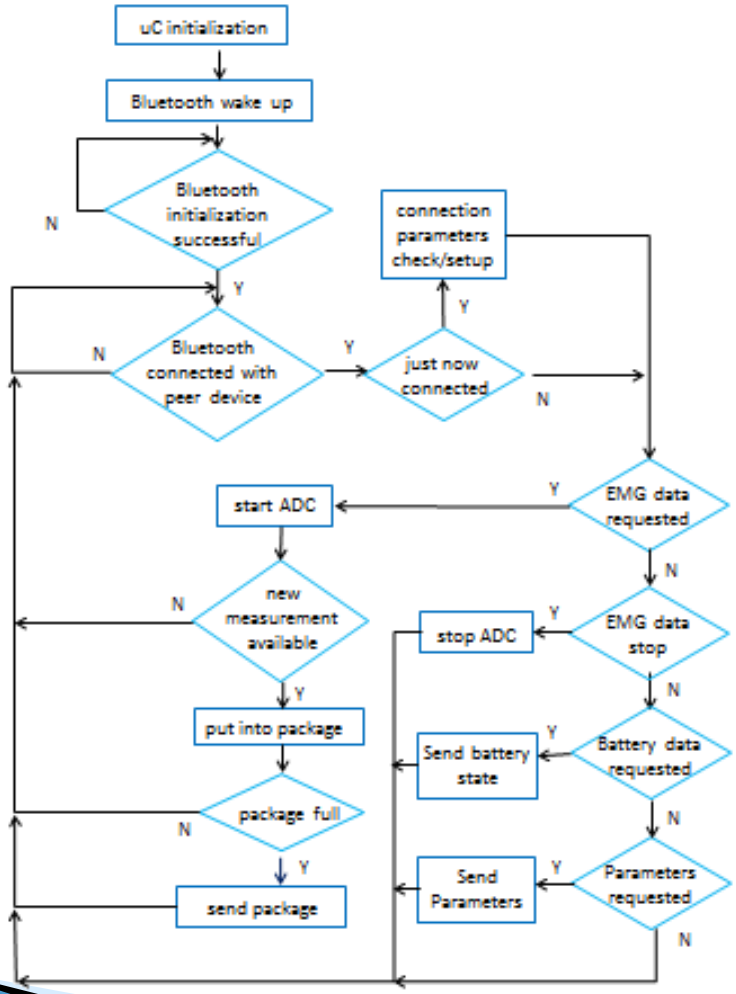
Software



- 2 software parts to design and program:
  - microcontroller
  - Android application

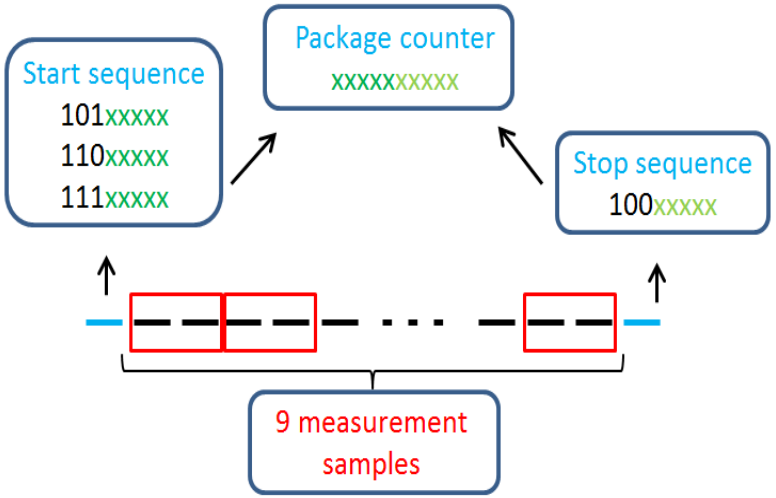
Software

Program structure



Data coding

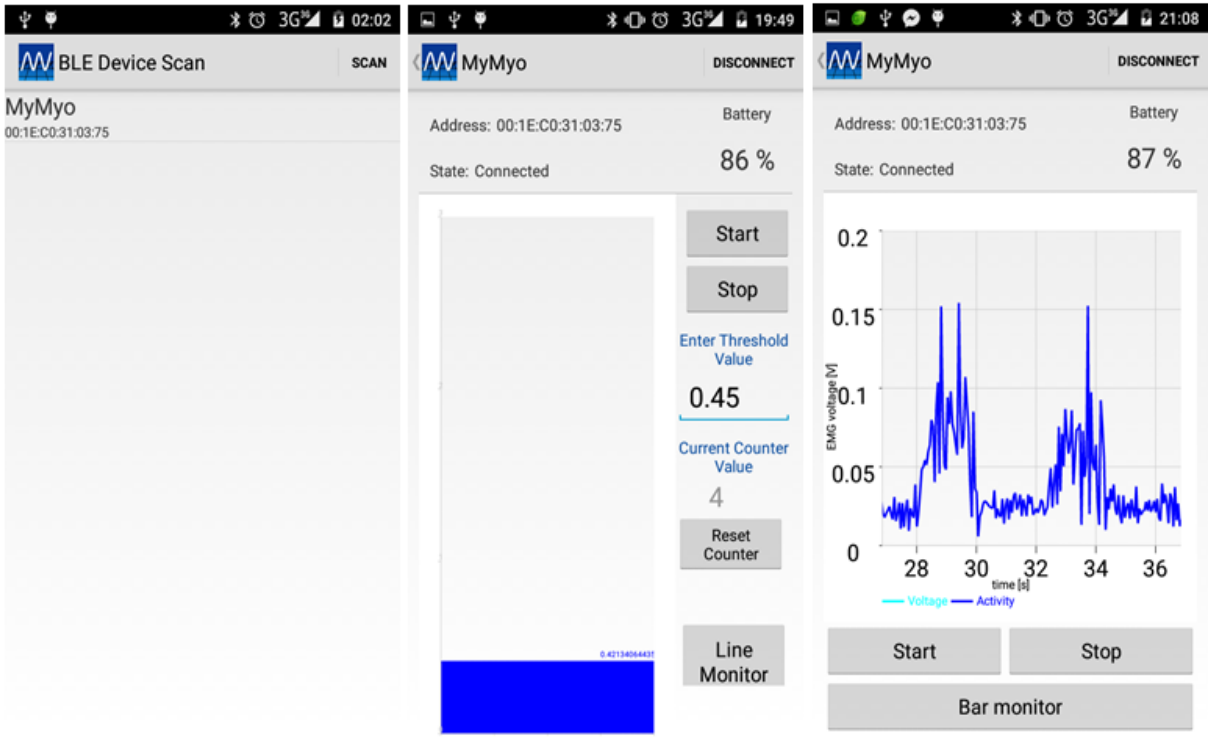
- 9 measurements into 20bytes packet



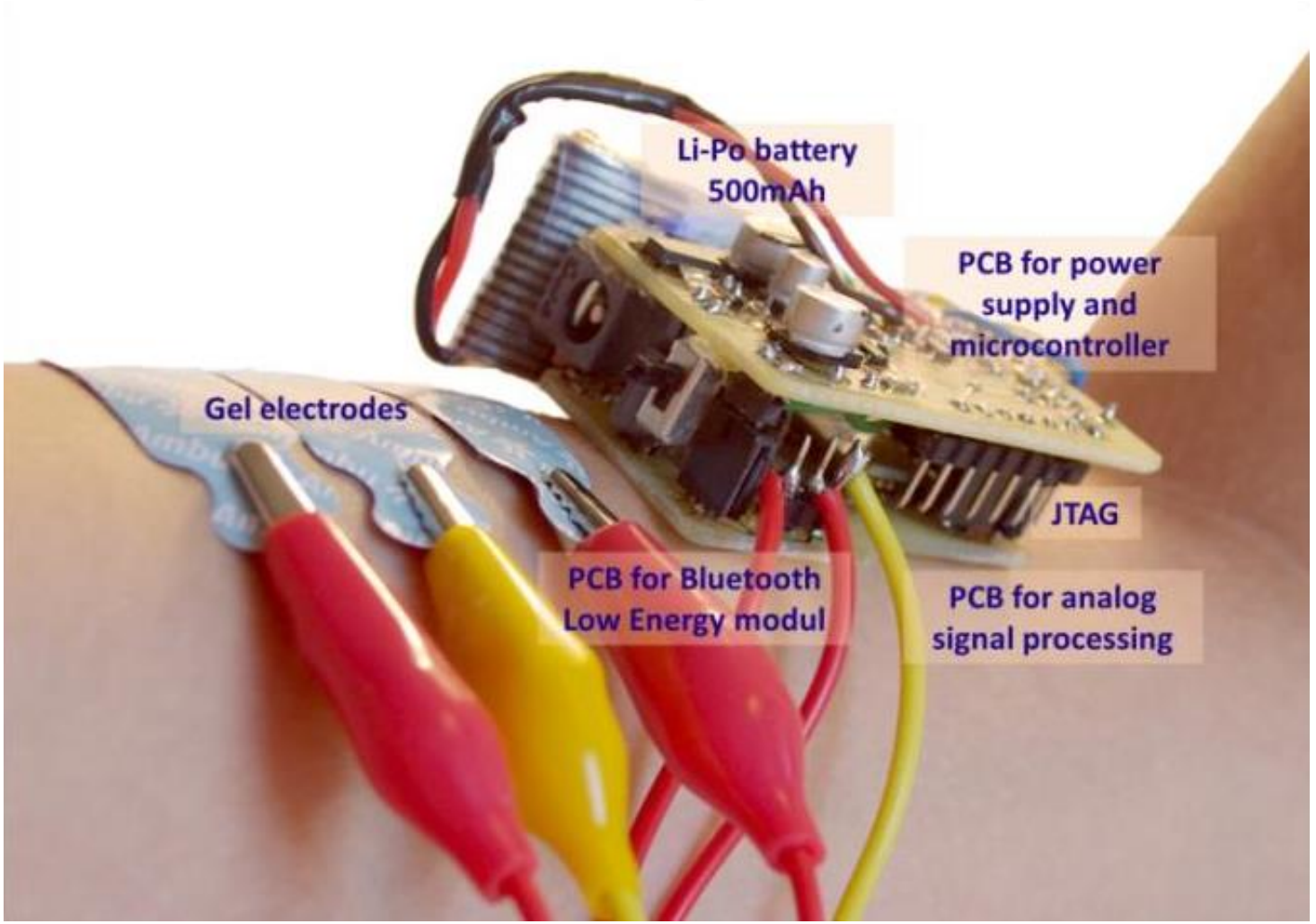
Command	BLE sequence	APP
Stop	101	EMG0
Start – EMG	101	EMG1
Start – Battery state	110	B
Start – Parameters	111	P

Android application

- visualisation of data
  - 2 display types
    - time lapse graph
    - bar graph
  - plotting is the bottleneck
    - plots with ~4Hz but ~80Hz of data
- data throughput
  - achieved $\sim 770Hz$
  - ideally 1 kHz
- storage of data on SD card
  - also too slow, has to be improved
- idea
  - connection of more devices at the same time
  - design depending on application
  - for physiotherapy
    - exercise definition
    - observes muscle activations
    - counts well performed exercises
    - to give suggestions …

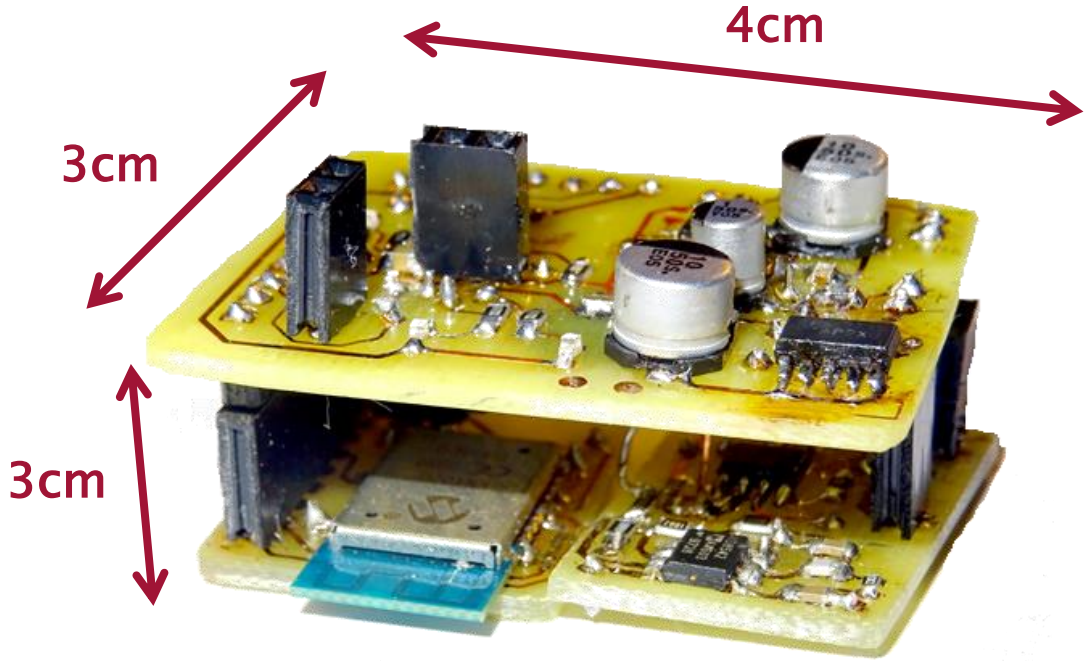


Device components



Current state

- whole data chain transfer designed, implemented and tested
  - microcontroller: sampling –> coding –> BLE
  - Android : decoding –> visualisation
- compact size prototype constructed



Future plans

- Hardware
  - reduce dimensions even more
  - design packaging
  - power consumption analysis
- Two electrode amplifier !

- Software
  - our own BLE profile
  - application enhancements
    - logging measurement data to SD card
    - more than one device connected simultaneously
    - muscle fatigue analysis
    - exercise definitions and analysis

Thank you! :)

Una.Pale@gmail.com