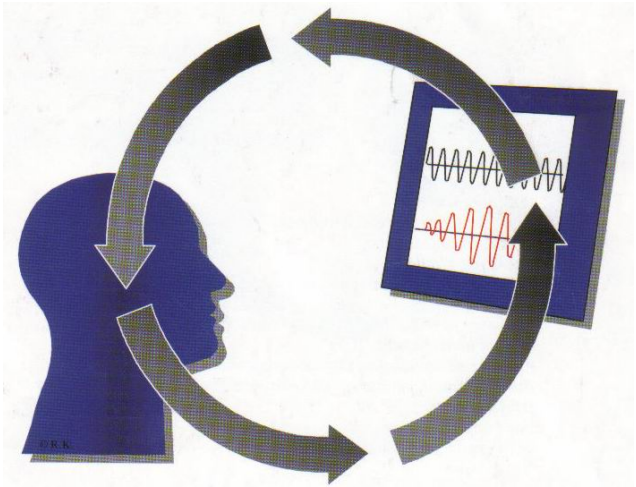
22. November 2011

Texas Instruments Analog Design Contest 2011

Biofeedback Device

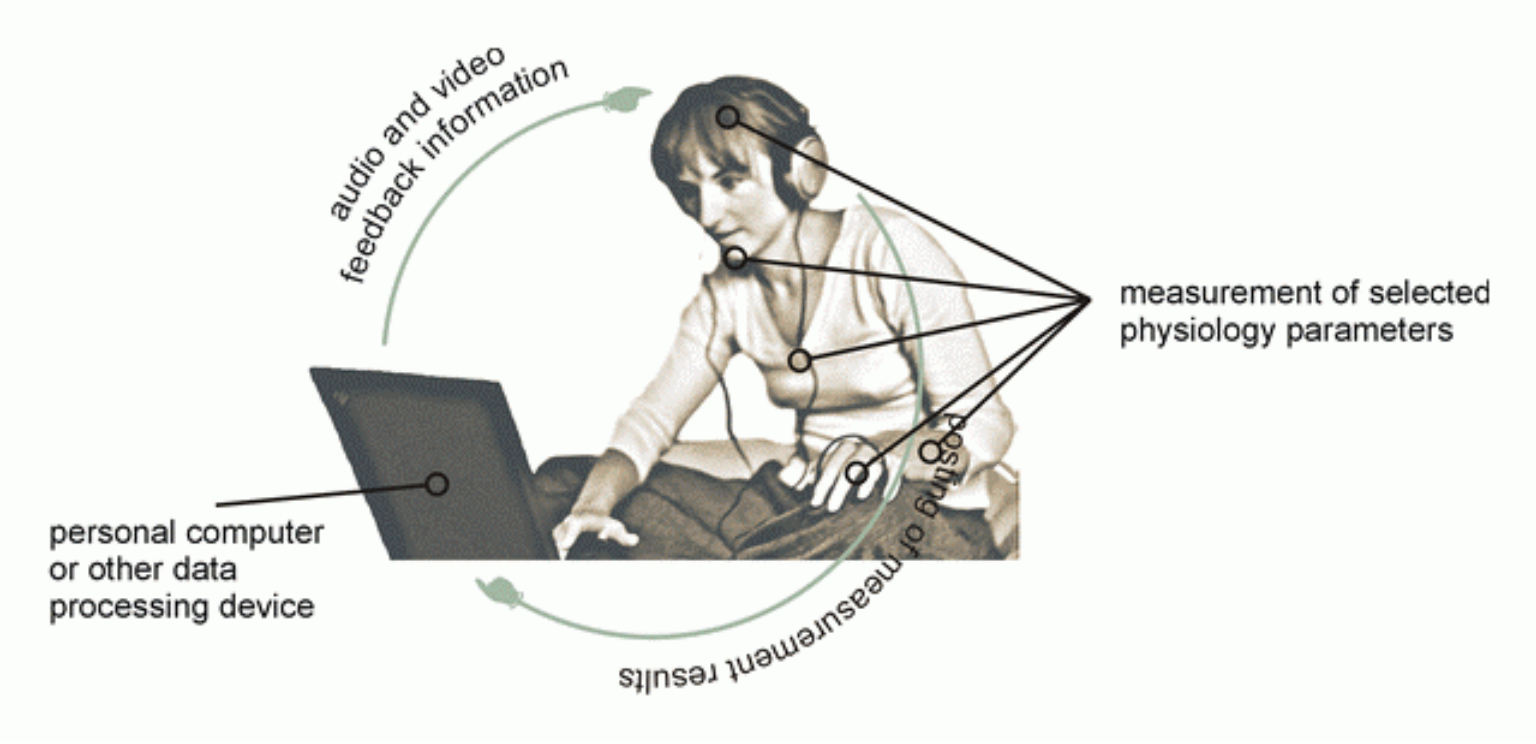
Michał Adamski
Janusz Frączek
Advising profesor: Antoni Grzanka
Warsaw University of Technology

Biofeedback device

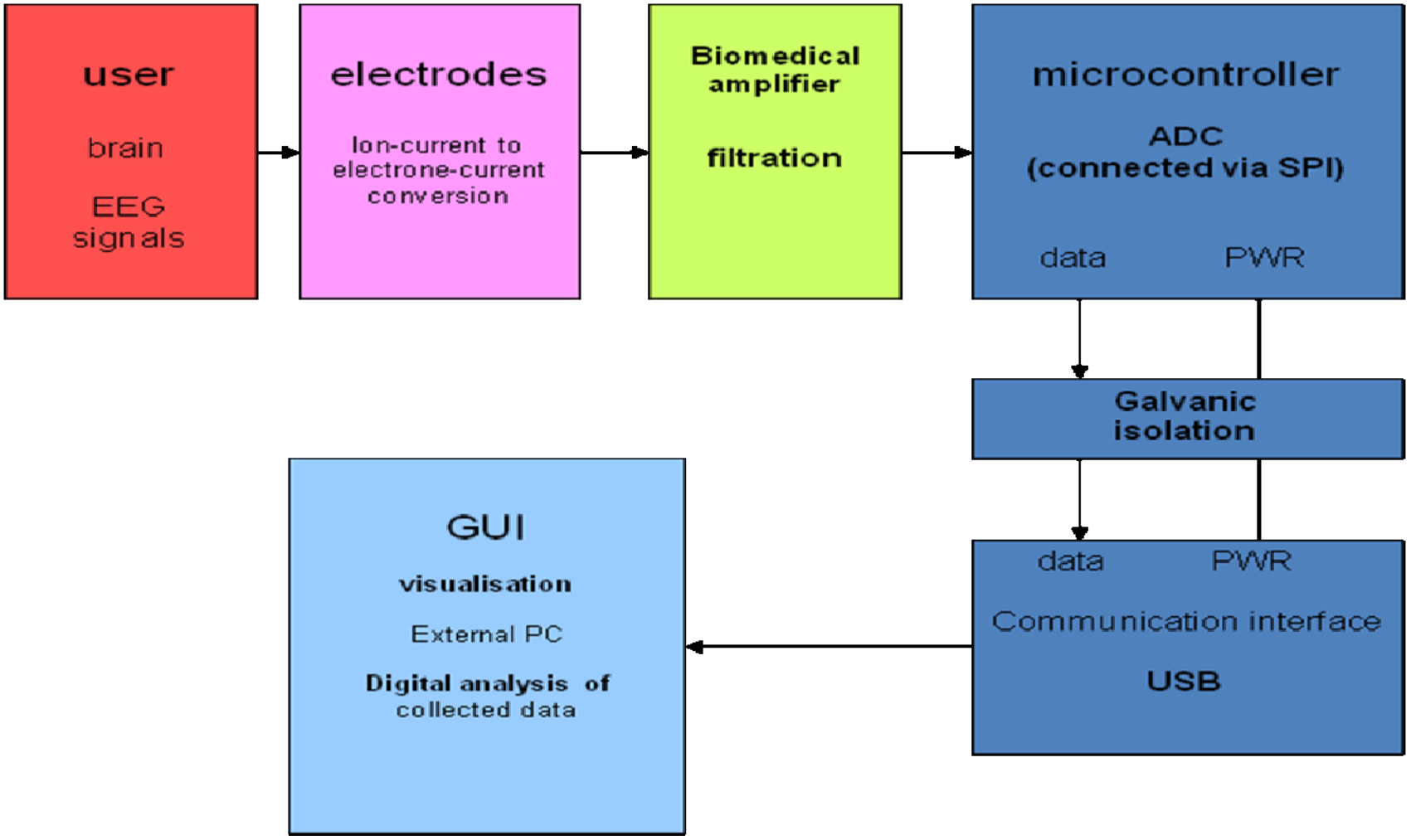


- What it is?
- Why do we need it?
- Can existing technology be harnessed in such a way us to allow a human operator to directly manipulate a computer through a brain actuated interface?
- Can it be achieved using a low-cost electronics?

How it works?


audio and video
feedback information
measurement of selected
physiology parameters
personal computer
or other data
processing device
posting of measurement results

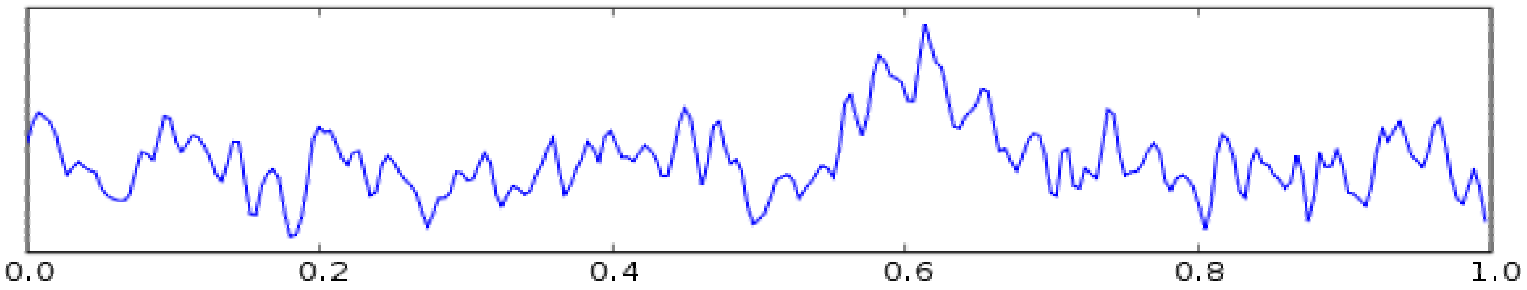
Block diagram



Brainwaves

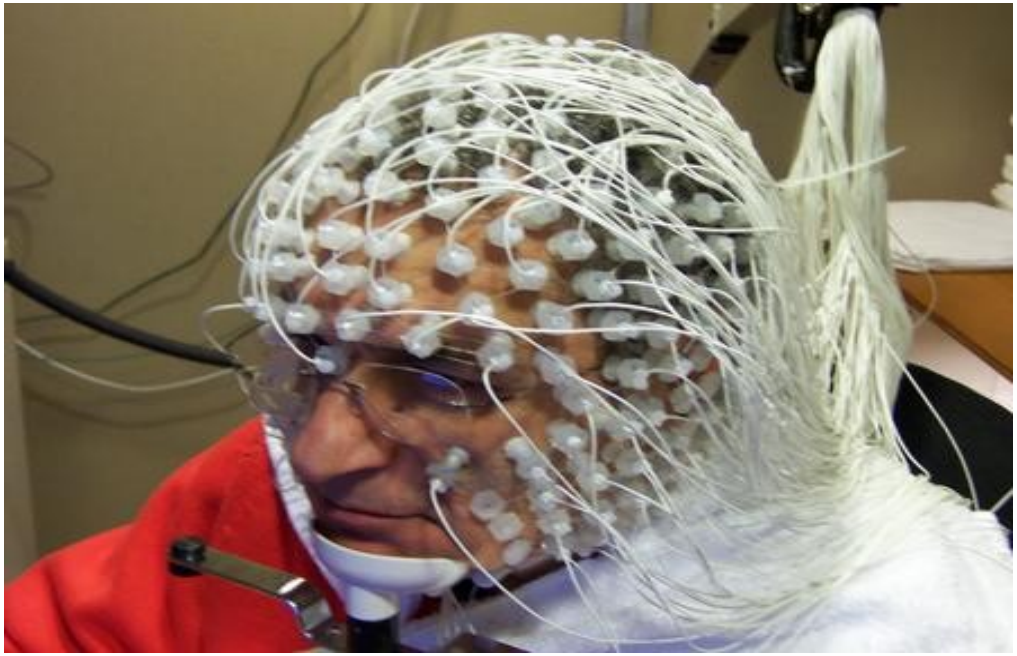
- Amplitude: 5-50 μV
- Frequency: 0-200 Hz
- Measurement problems
  - Low signal amplitude
  - High noise level
  - High skin impedance

- Delta: 1 – 4 [Hz]
- Theta: 4 – 8 [Hz]
- Alpha: 8 – 12 [Hz]
- Beta: 12 – 40 [Hz]
- Gamma: > 40 [Hz]

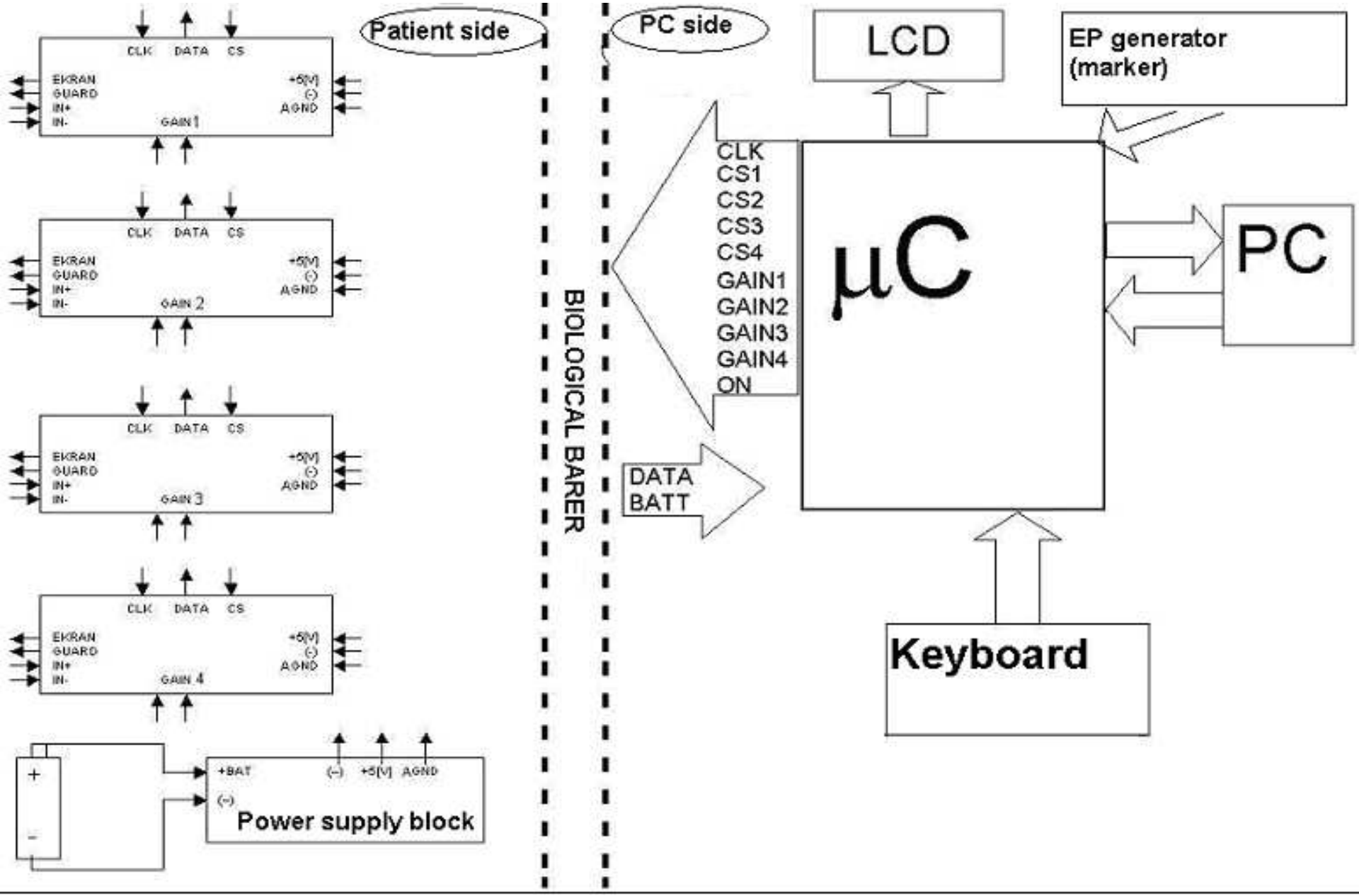


Electrodes

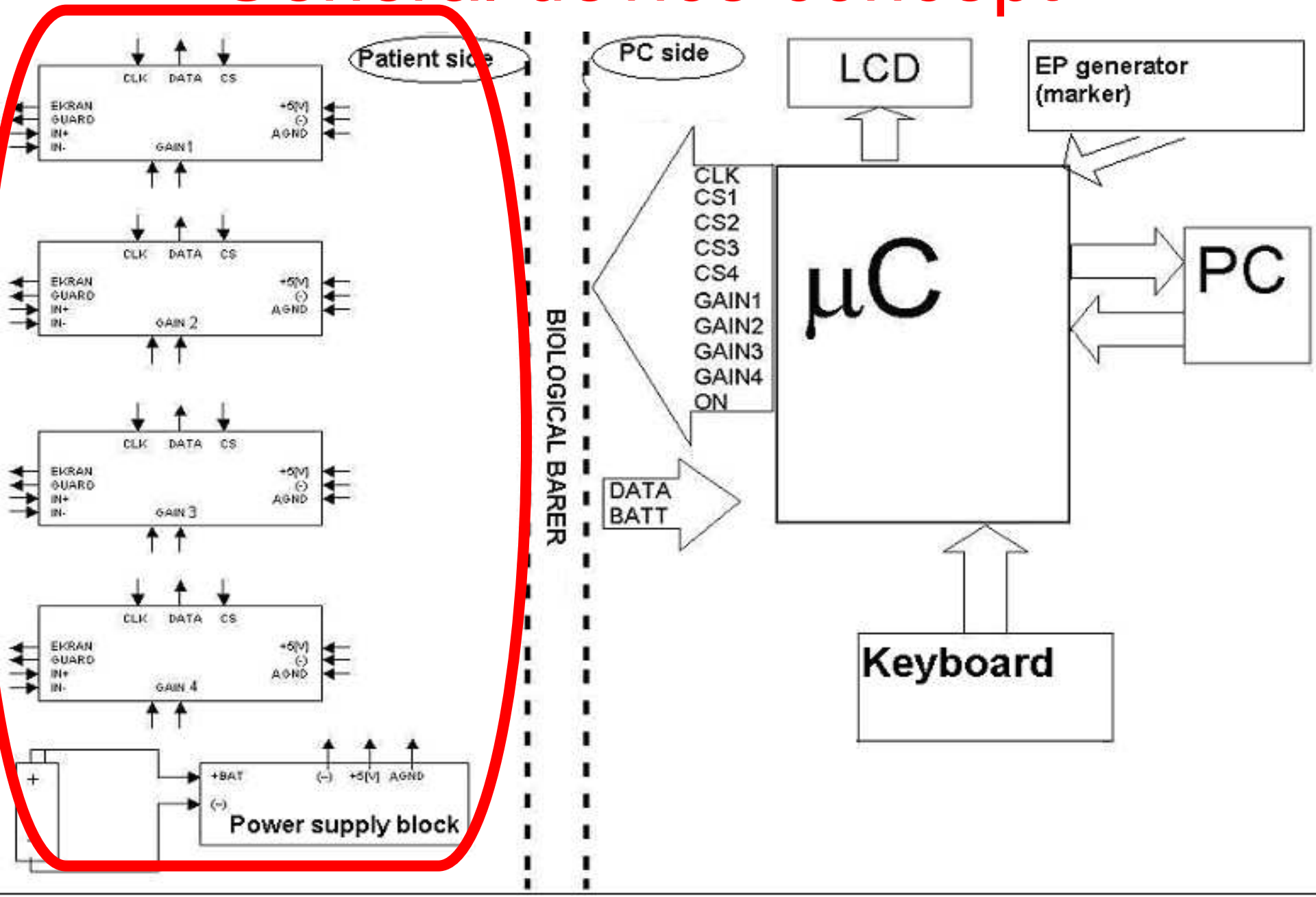
- Ion to electrone current convertion
- AgCl electrodes, as economic and easy solution
- Active electrodes – advantages and disadvantages



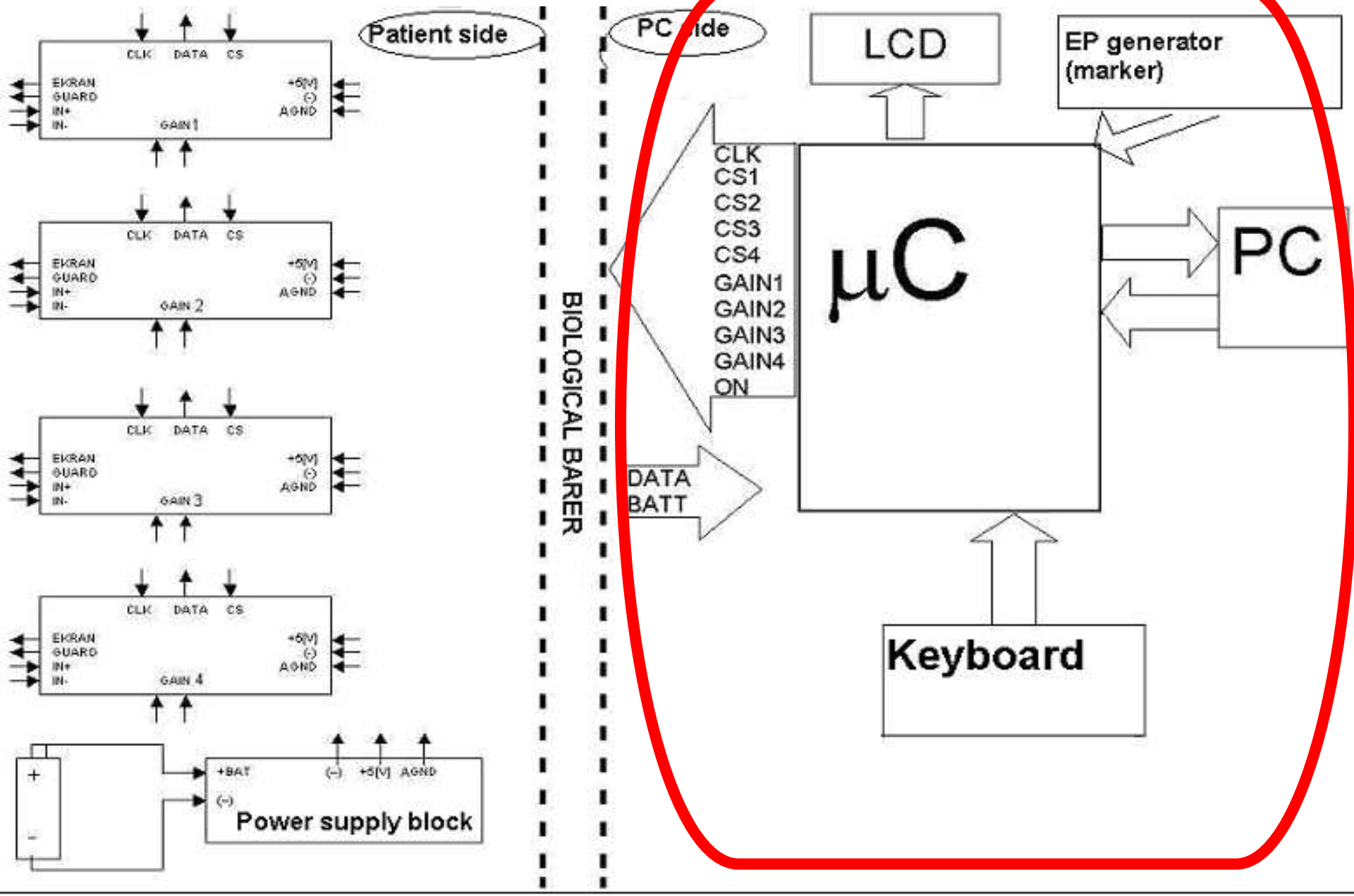
General device concept



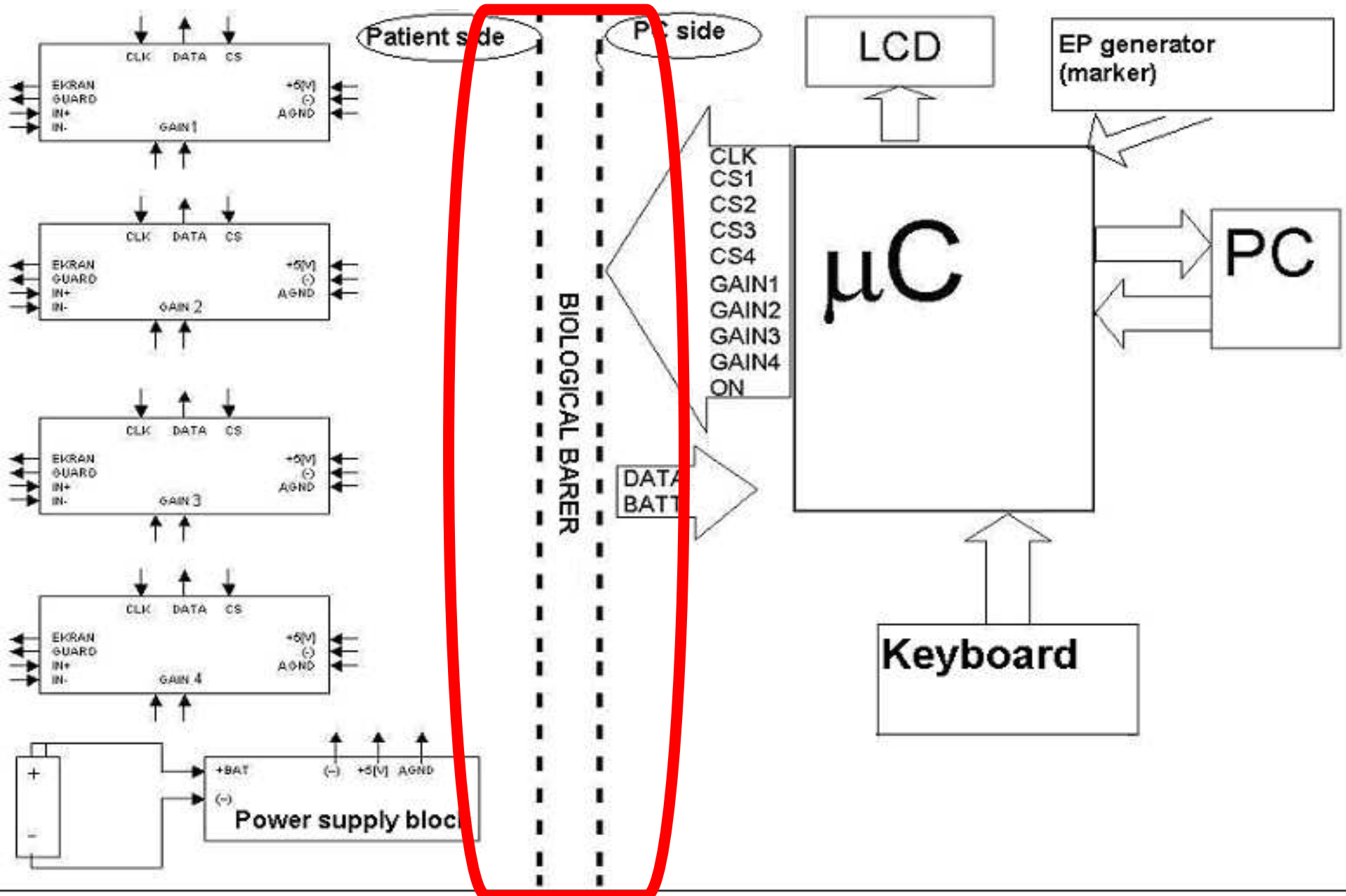
General device concept



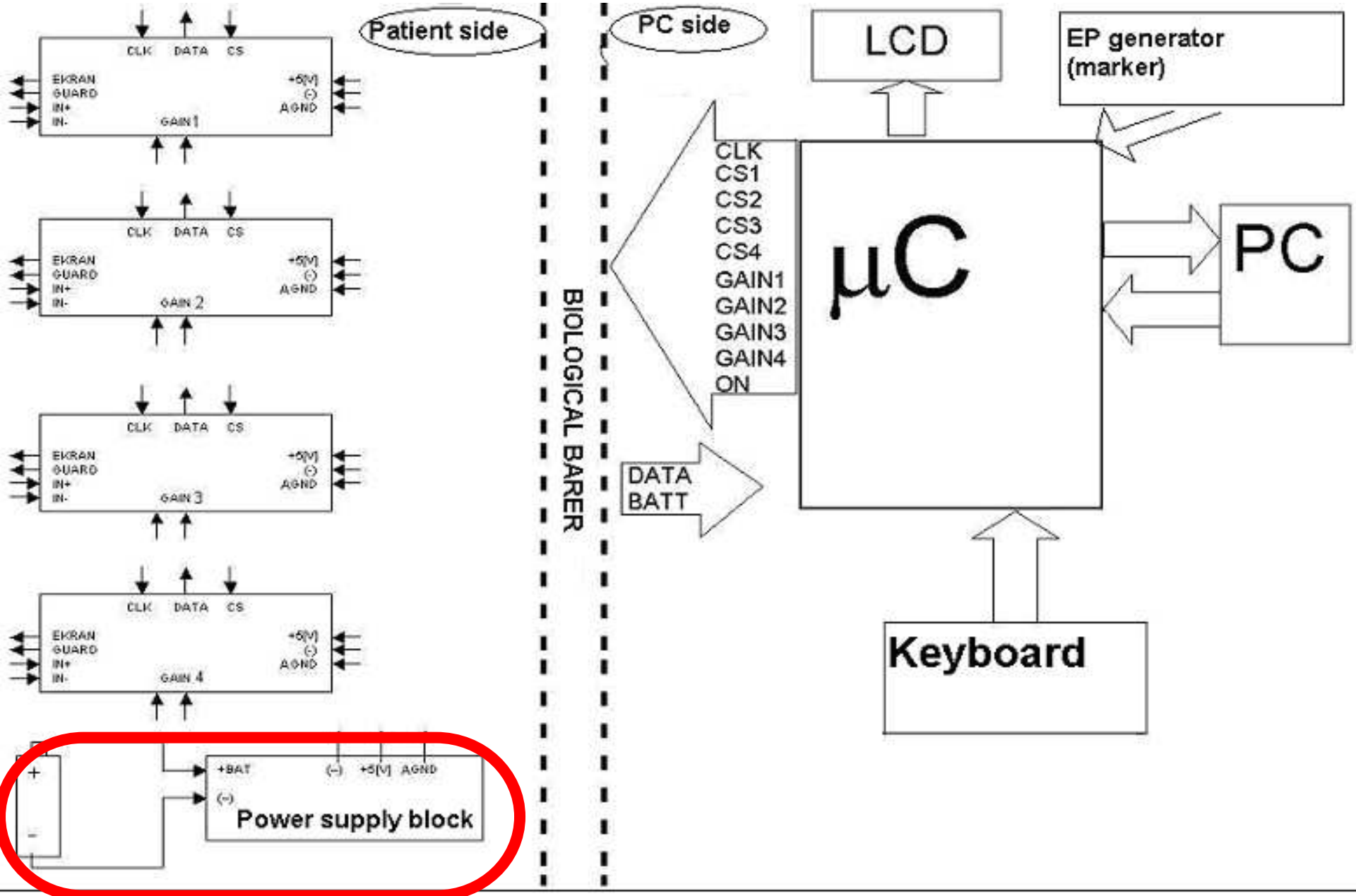
General device concept



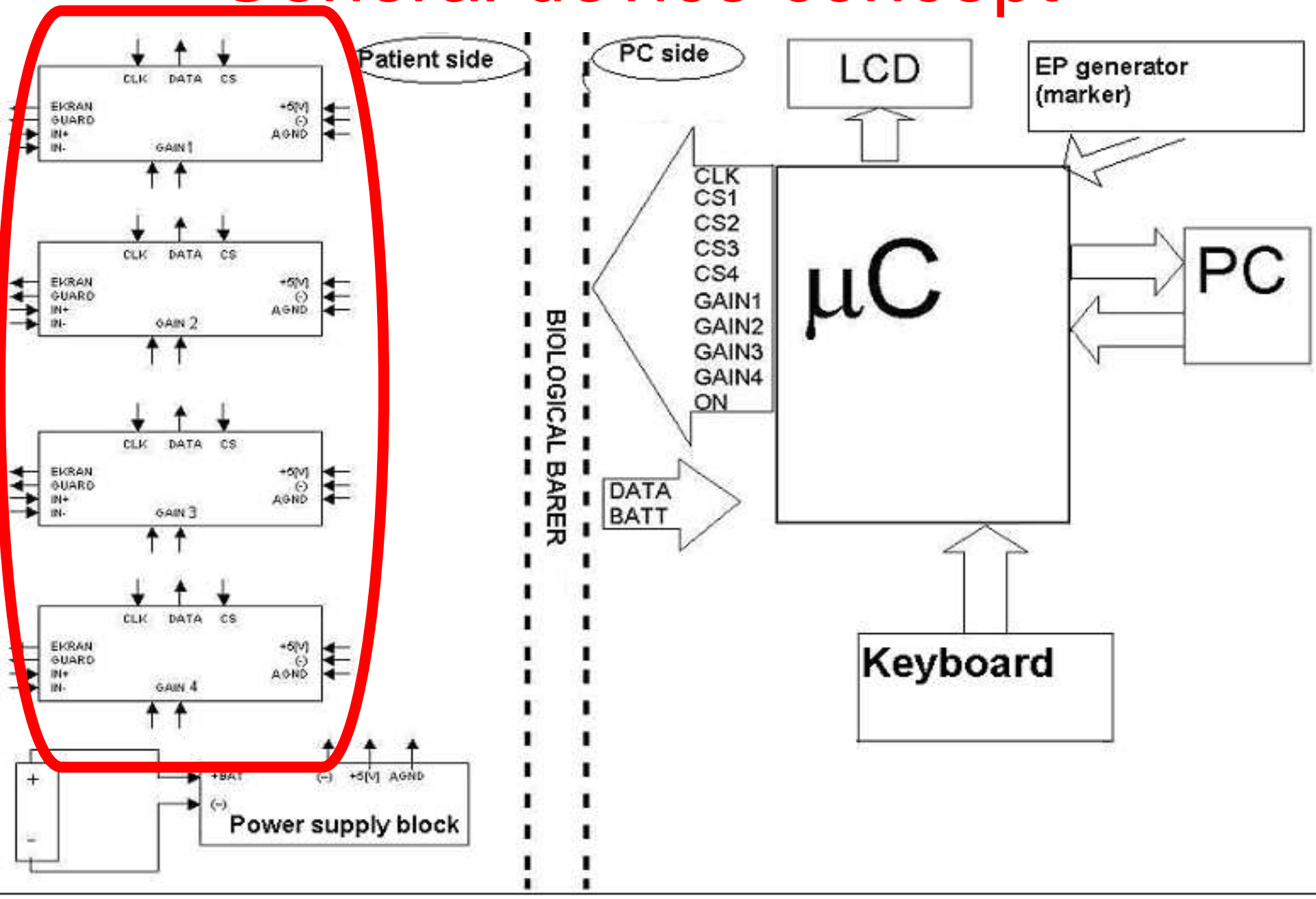
General device concept



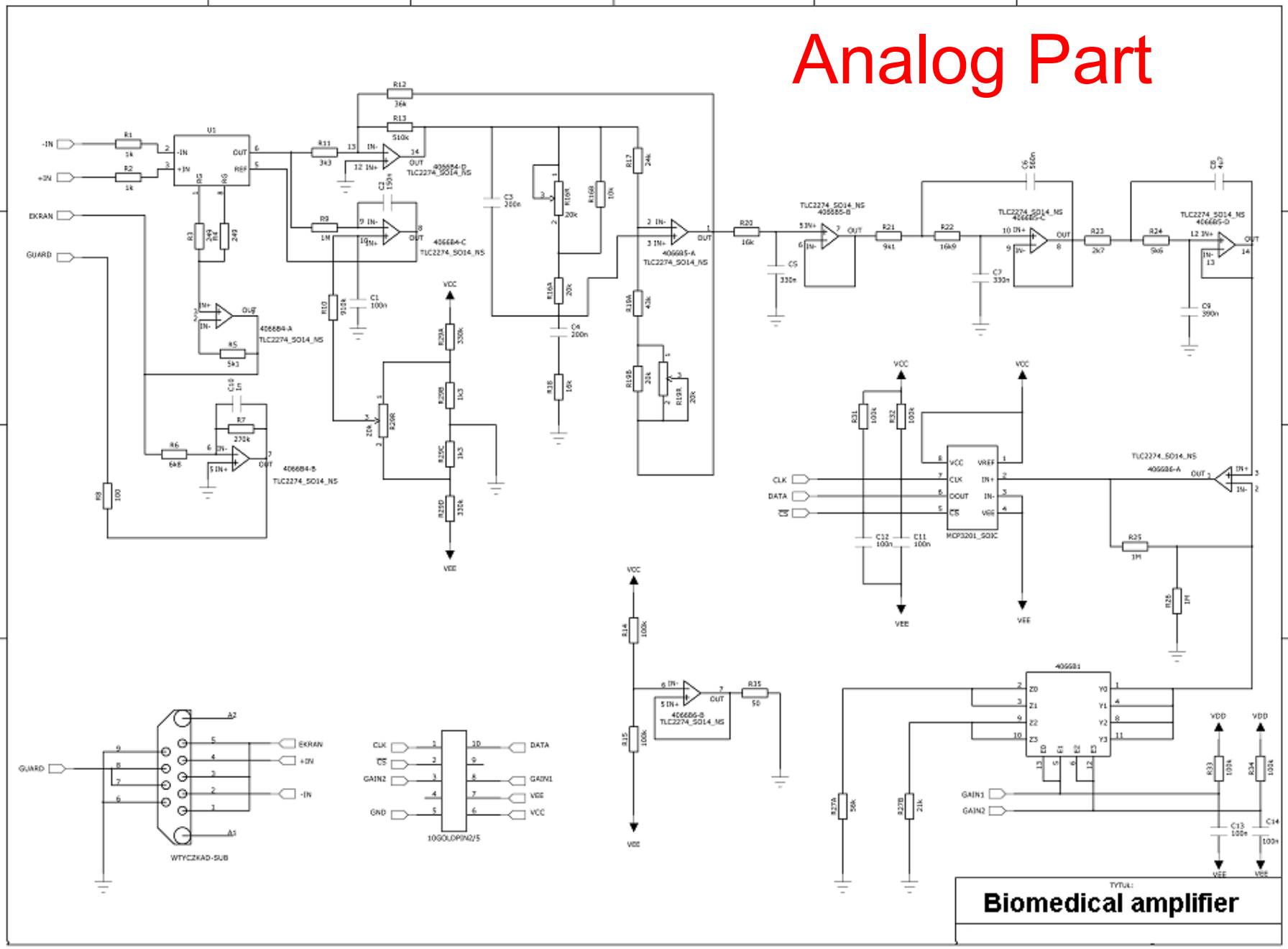
General device concept

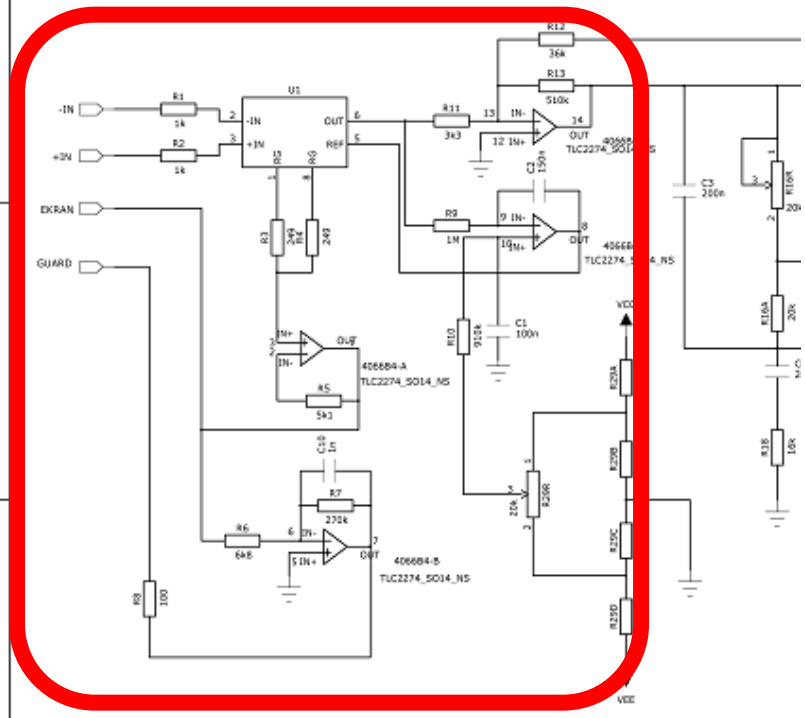


General device concept



Analog Part


-IN
+IN
EKRAN
GUARD
U1
TLC2274_SO14_NS
MCP3201_SOIC
WTYCZKAD-SUB
10GOLDPIN2/5
TYTUŁ:
Biomedical amplifier



1st stage of amplification G=100V/V

-low noise

-high CMRR

-high input impedance

-FET or CMOS

-low quiescent current

Active HP Filtration

-prevents from saturation

-cuts off DC component

-attenuates freqencies below 1.5[Hz]

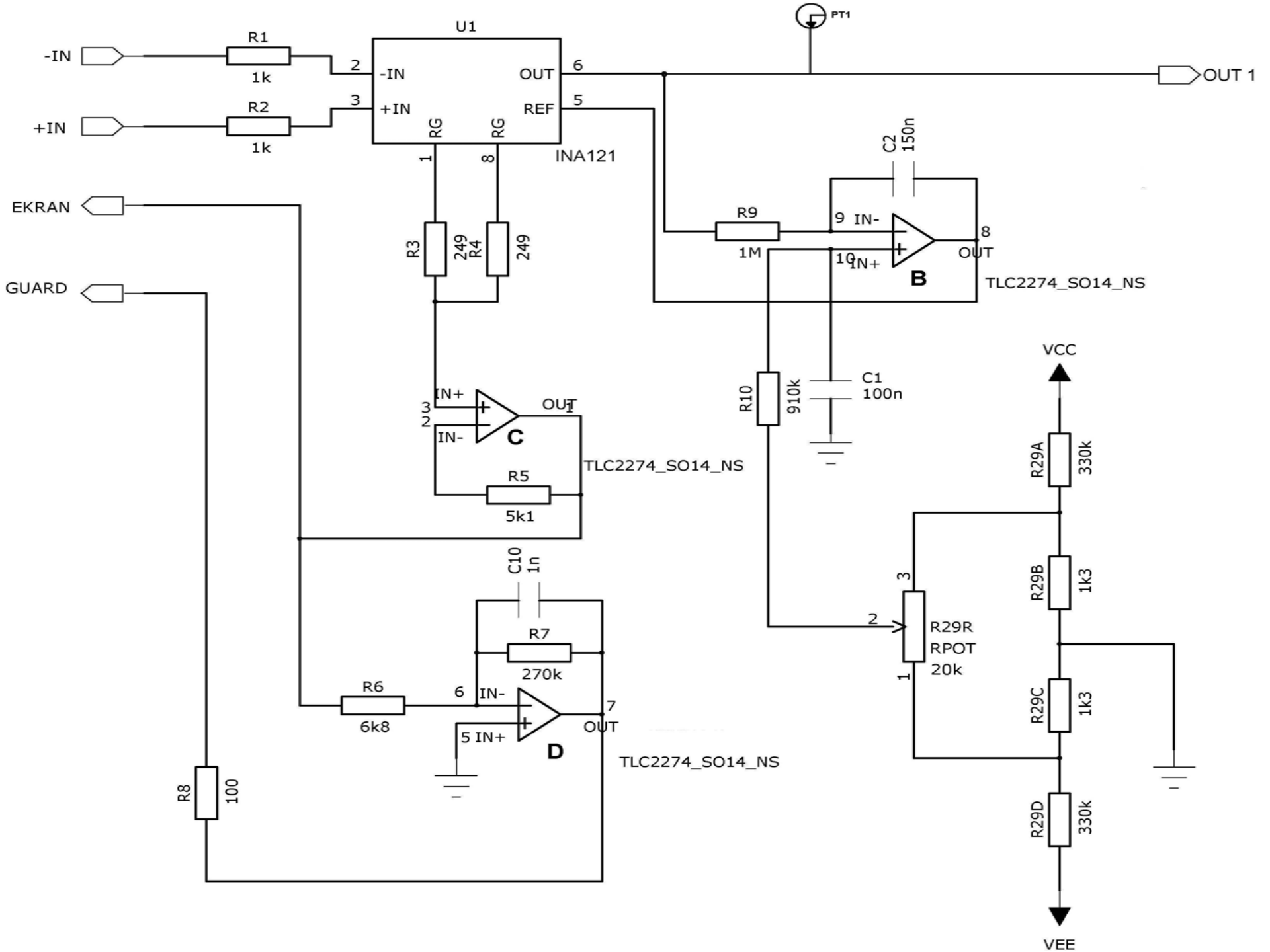
Bootstrap

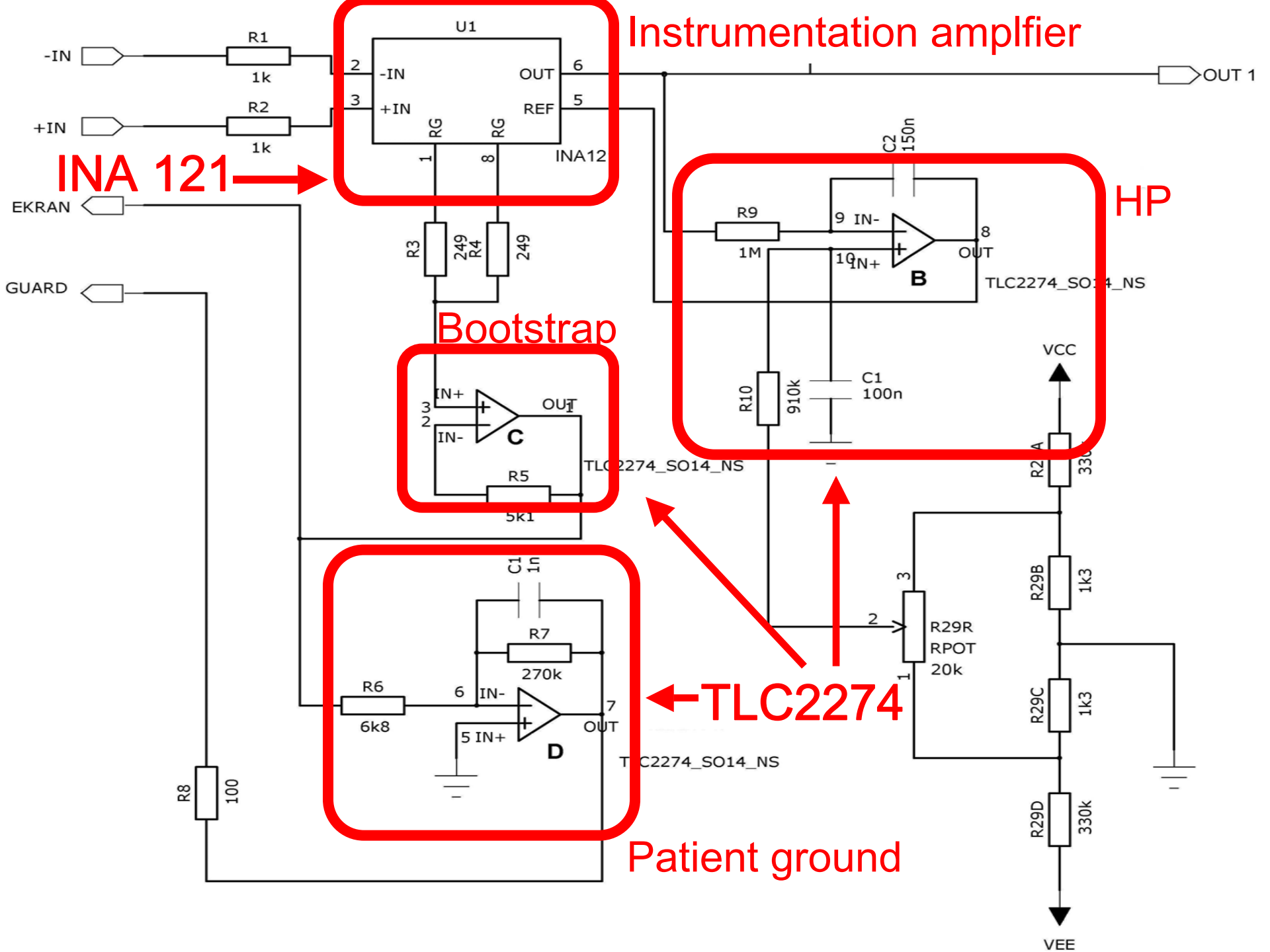
-to reduce input capacitance (noise)

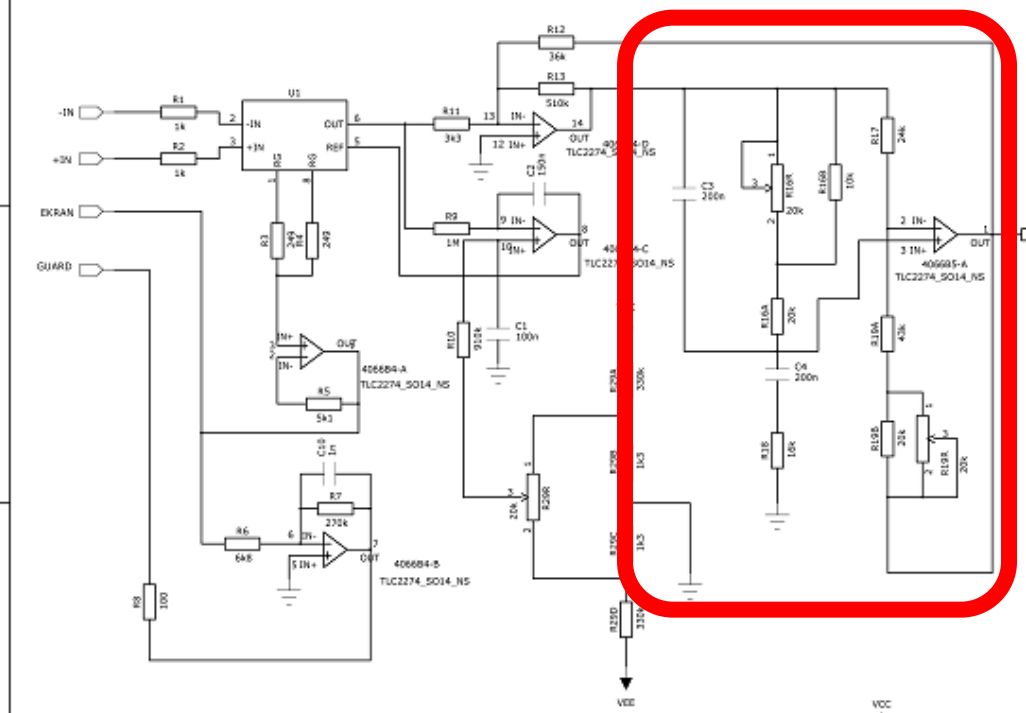
Patient active ground

-to reduce common signal

- to set up common ground (referenc


-IN
+IN
R1
1k
R2
1k
U1
-IN
+IN
RG
RG
OUT
REF
INA121
PT1
OUT 1
EKRAN
GUARD
R3
249
R4
249
C2
150n
R9
1M
IN-
IN+
OUT
B
TLC2274_SO14_NS
R10
910k
C1
100n
VCC
VEE
R29A
330k
R29B
1k3
R29R
RPOT
20k
R29C
1k3
R29D
330k
IN+
IN-
OUT
C
TLC2274_SO14_NS
R5
5k1
C10
1n
R7
270k
R6
6k8
IN-
IN+
OUT
D
TLC2274_SO14_NS
R8
100


Instrumentation amplfier
INA 121
HP
Bootstrap
TLC2274
Patient ground
-IN
+IN
R1
1k
R2
1k
U1
-IN
+IN
RG
RG
OUT
REF
INA12
OUT 1
EKRAN
GUARD
R3
249
R4
249
C2
150n
R9
1M
IN-
IN+
OUT
B
TLC2274_SO14_NS
R10
910k
C1
100n
VCC
C
IN+
IN-
OUT
R5
5k1
TLC2274_SO14_NS
C1
1n
R7
270k
R6
6k8
IN-
IN+
OUT
D
TLC2274_SO14_NS
R8
100
R29R
RPOT
20k
R29B
1k3
R29C
1k3
R29D
330k
VEE



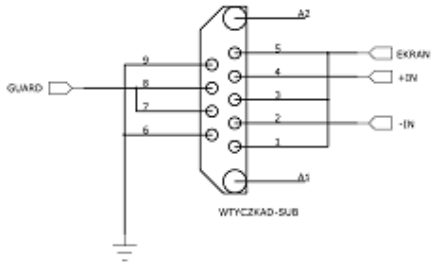
2nd stage of amplification G=10 V/V

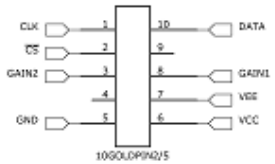
-provides more stability than one stage of amplification

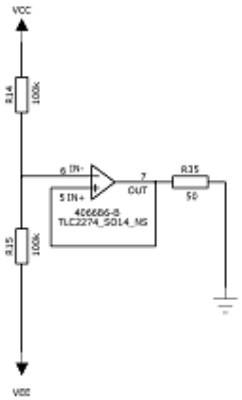
Notch filter

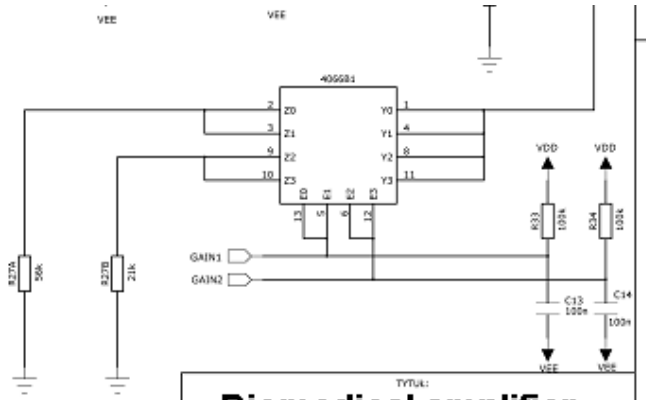
-to cut off mains freqency (50Hz)

-based on Wien-Robinson bridge



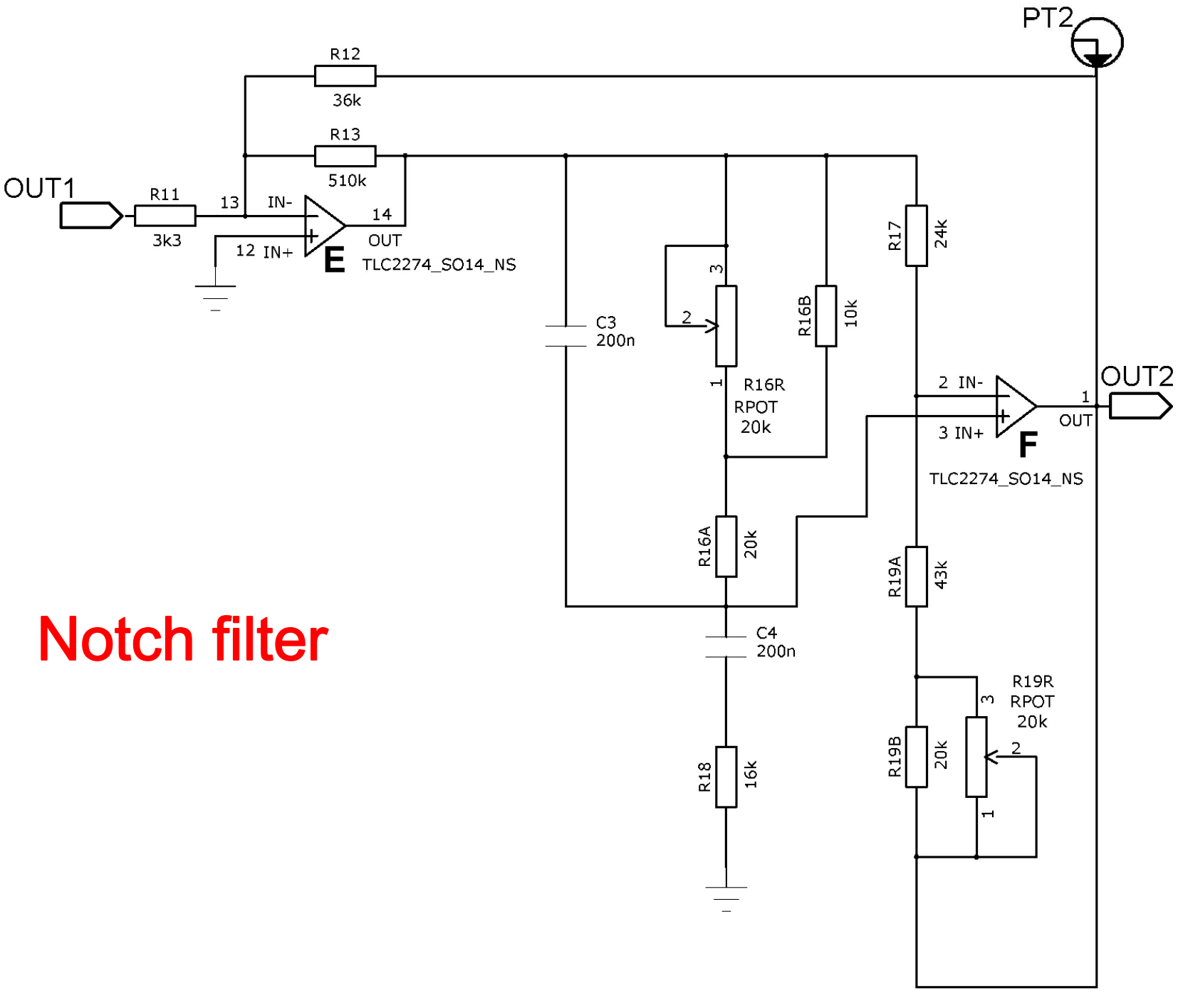




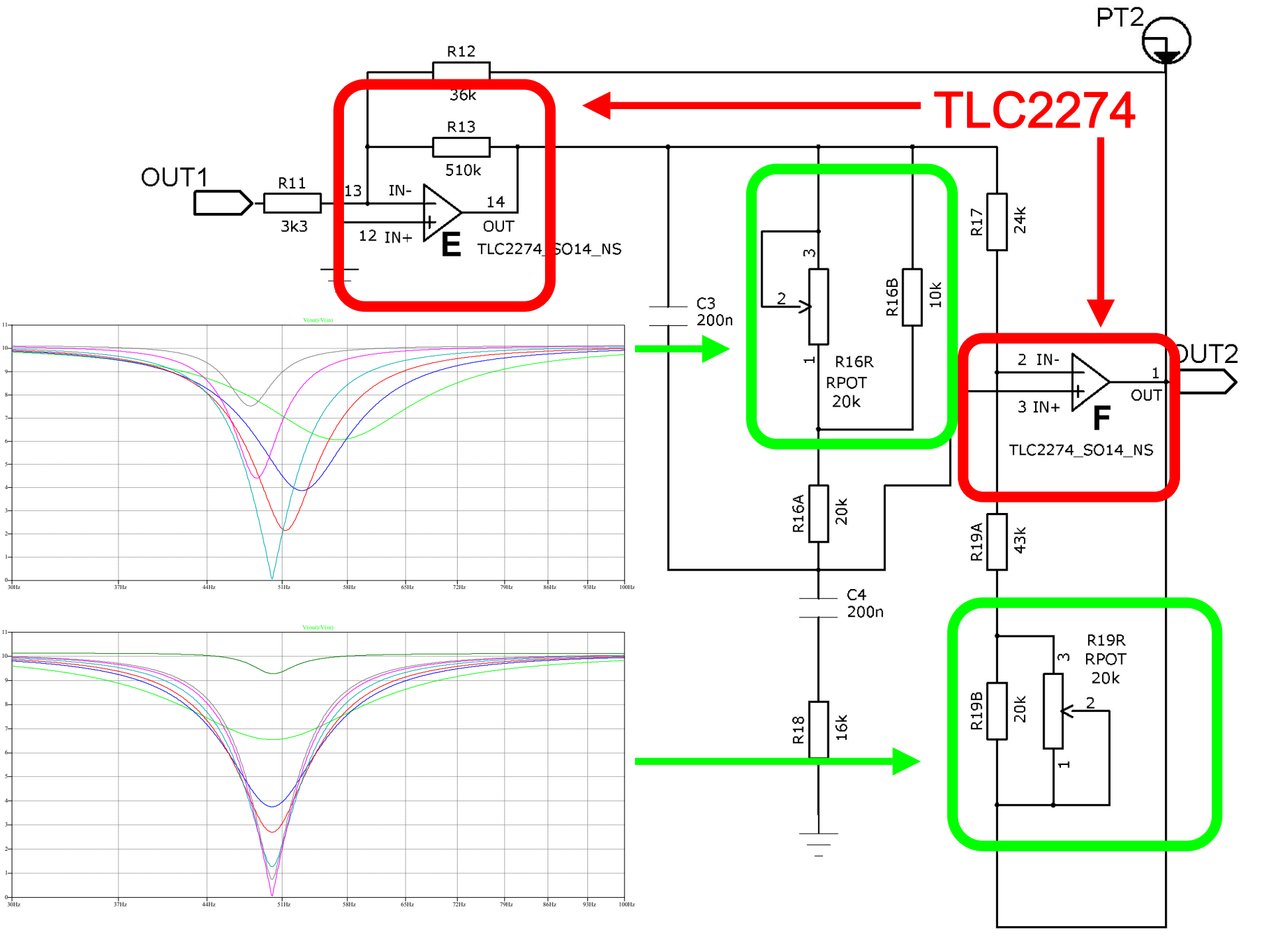


TYTUŁ:

Biomedical amplifier



Notch filter

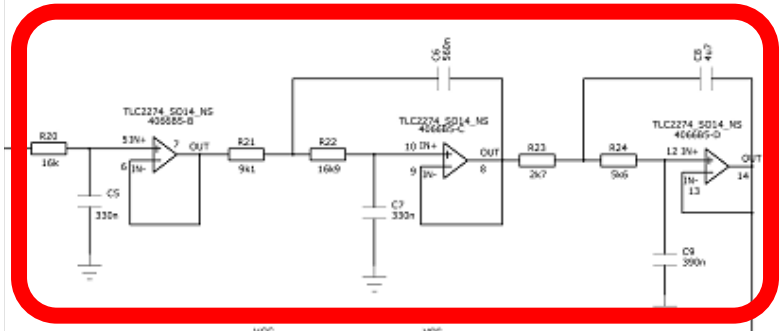

PT2
TLC2274
R12
36k
R13
510k
OUT1
R11
3k3
13
IN-
12 IN+
14
OUT
E
TLC2274_SO14_NS
C3
200n
R16R
RPOT
20k
R16B
10k
R17
24k
R16A
20k
R19A
43k
C4
200n
R18
16k
2 IN-
3 IN+
1
OUT
F
TLC2274_SO14_NS
OUT2
R19R
RPOT
20k
R19B
20k
V(out)/V(in)
30Hz
37Hz
44Hz
51Hz
58Hz
65Hz
72Hz
79Hz
86Hz
93Hz
100Hz

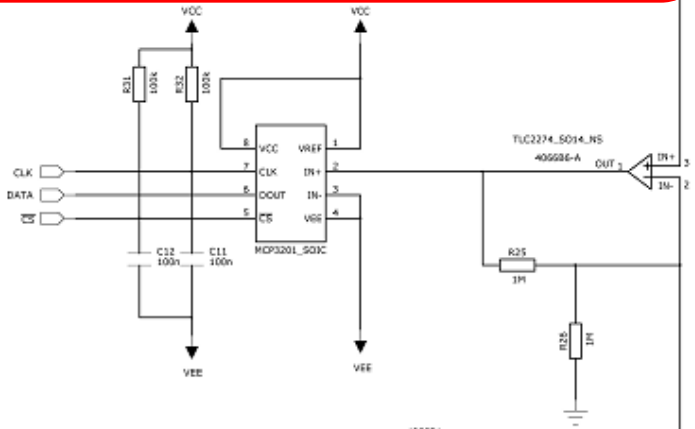
LP filter

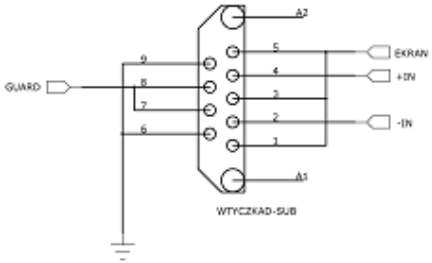
-5th order

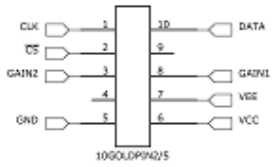
-Salen-Key architecture

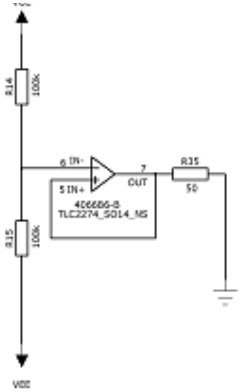
-attenuates frequencies over 30Hz

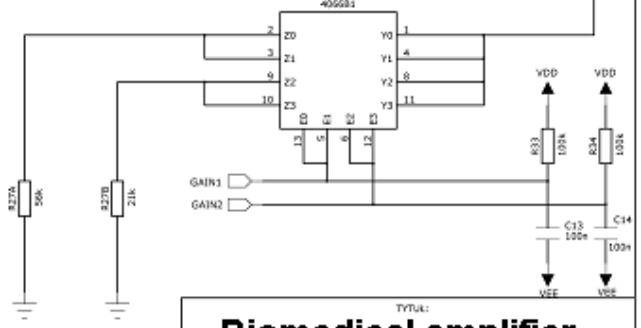






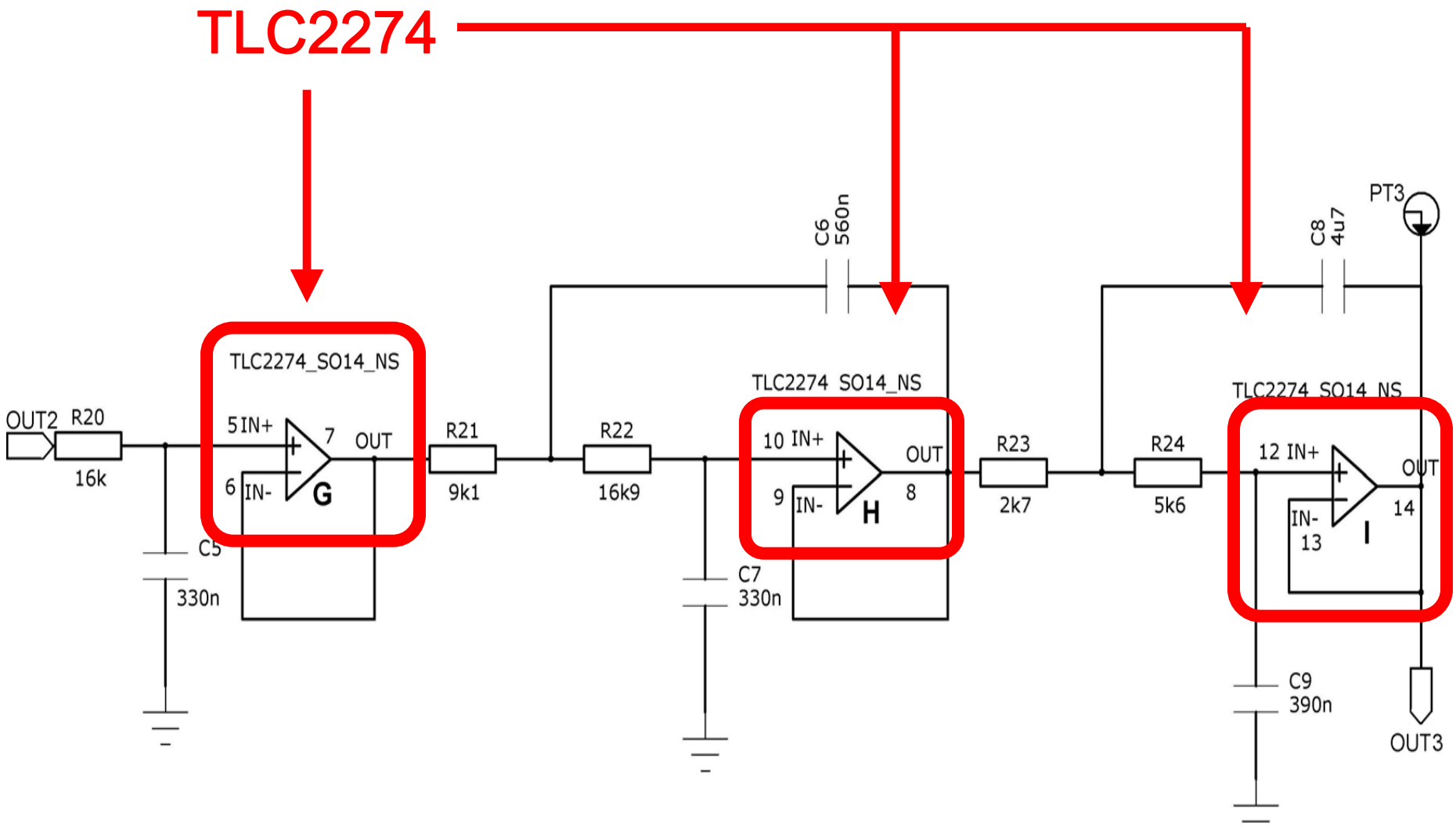




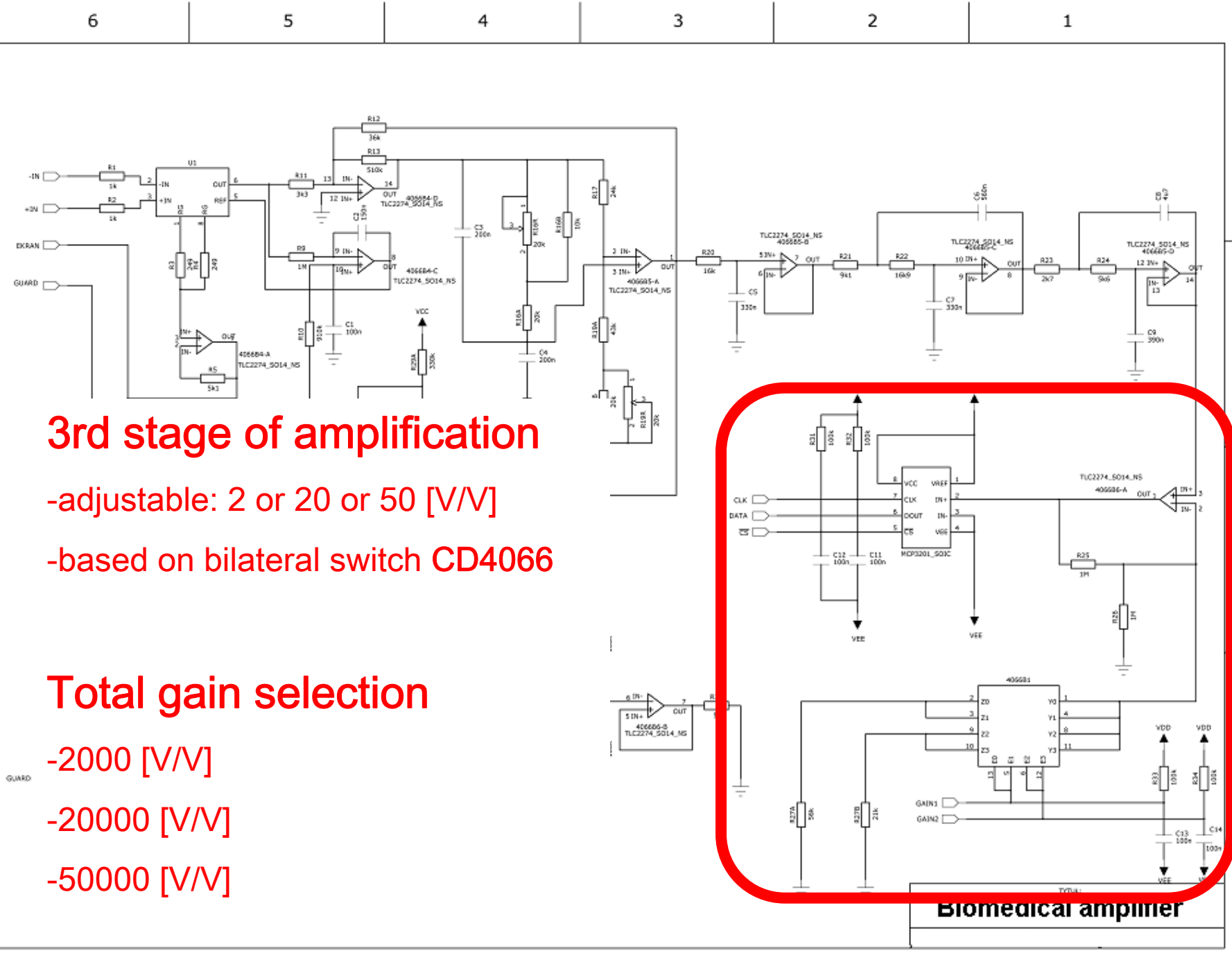


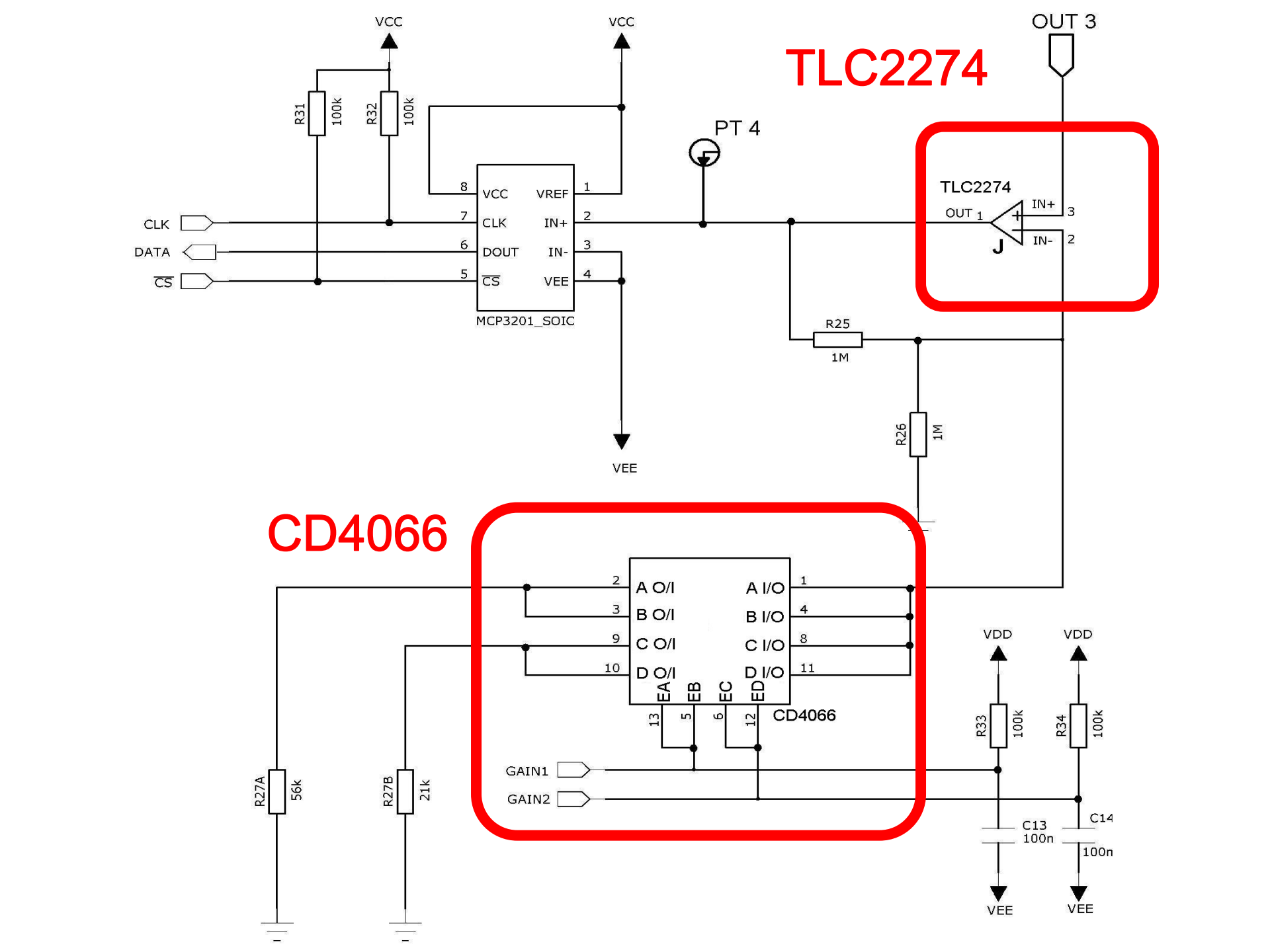
TYTUŁ:

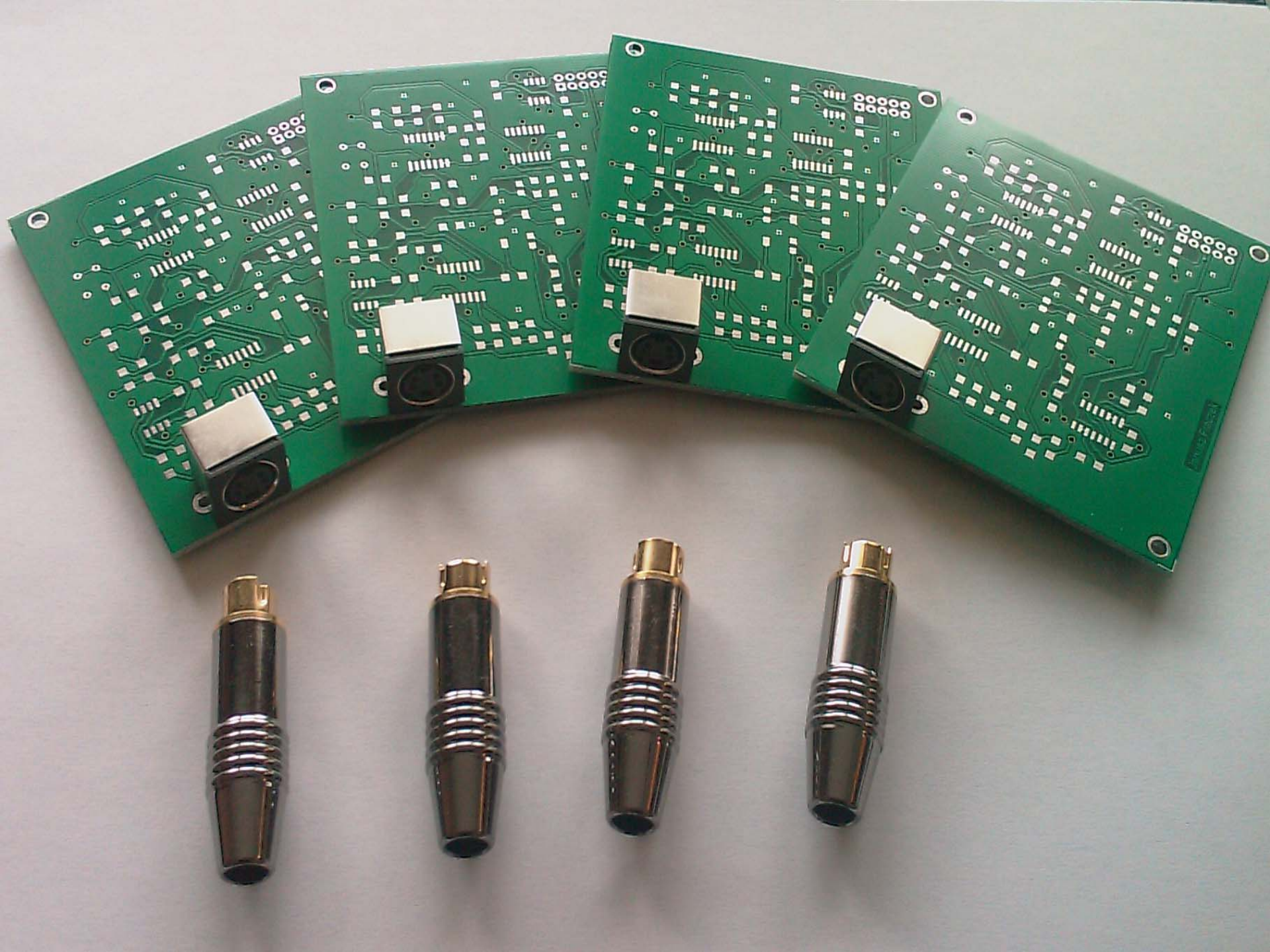
Biomedical amplifier

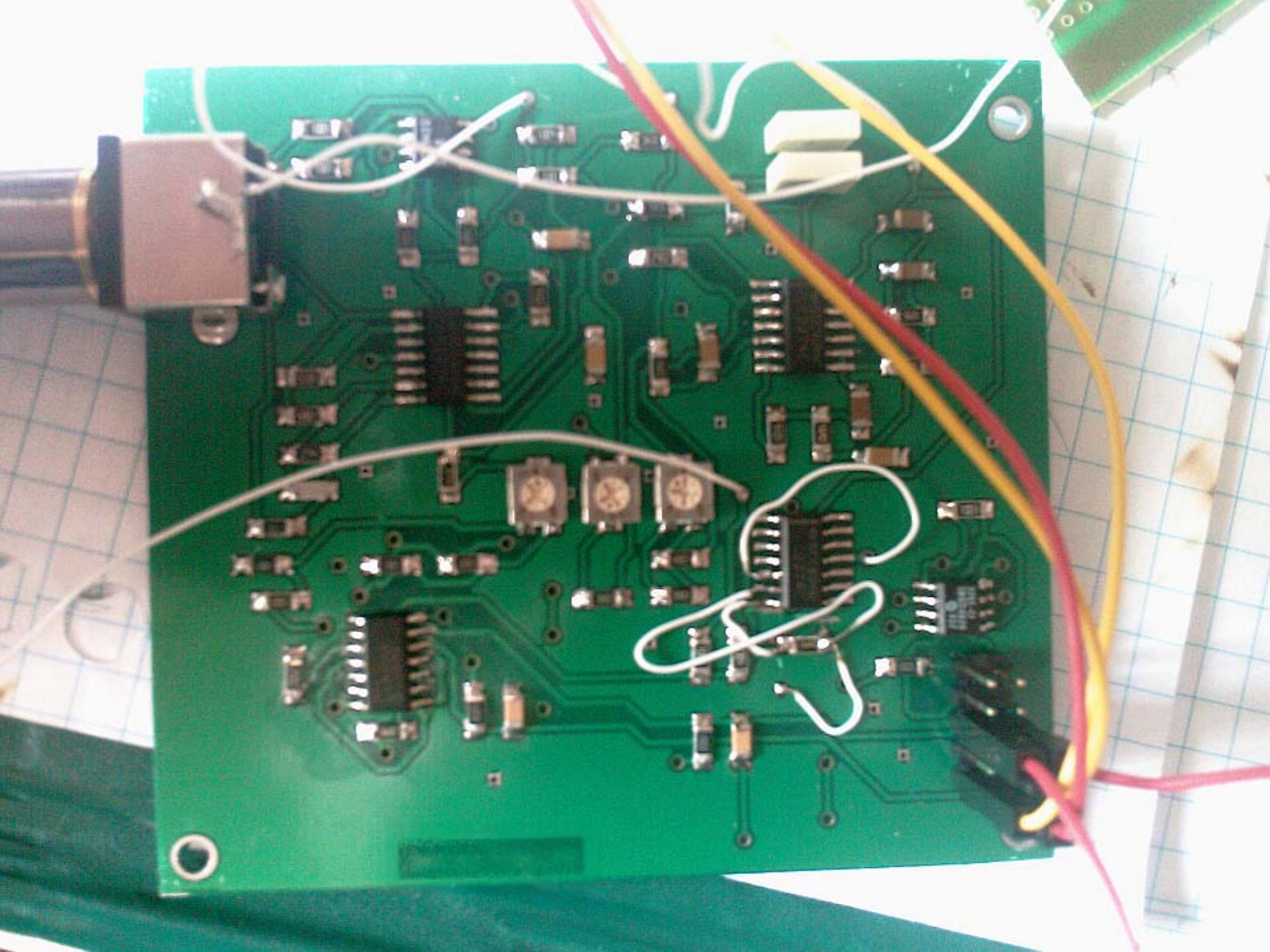


Low pass filter

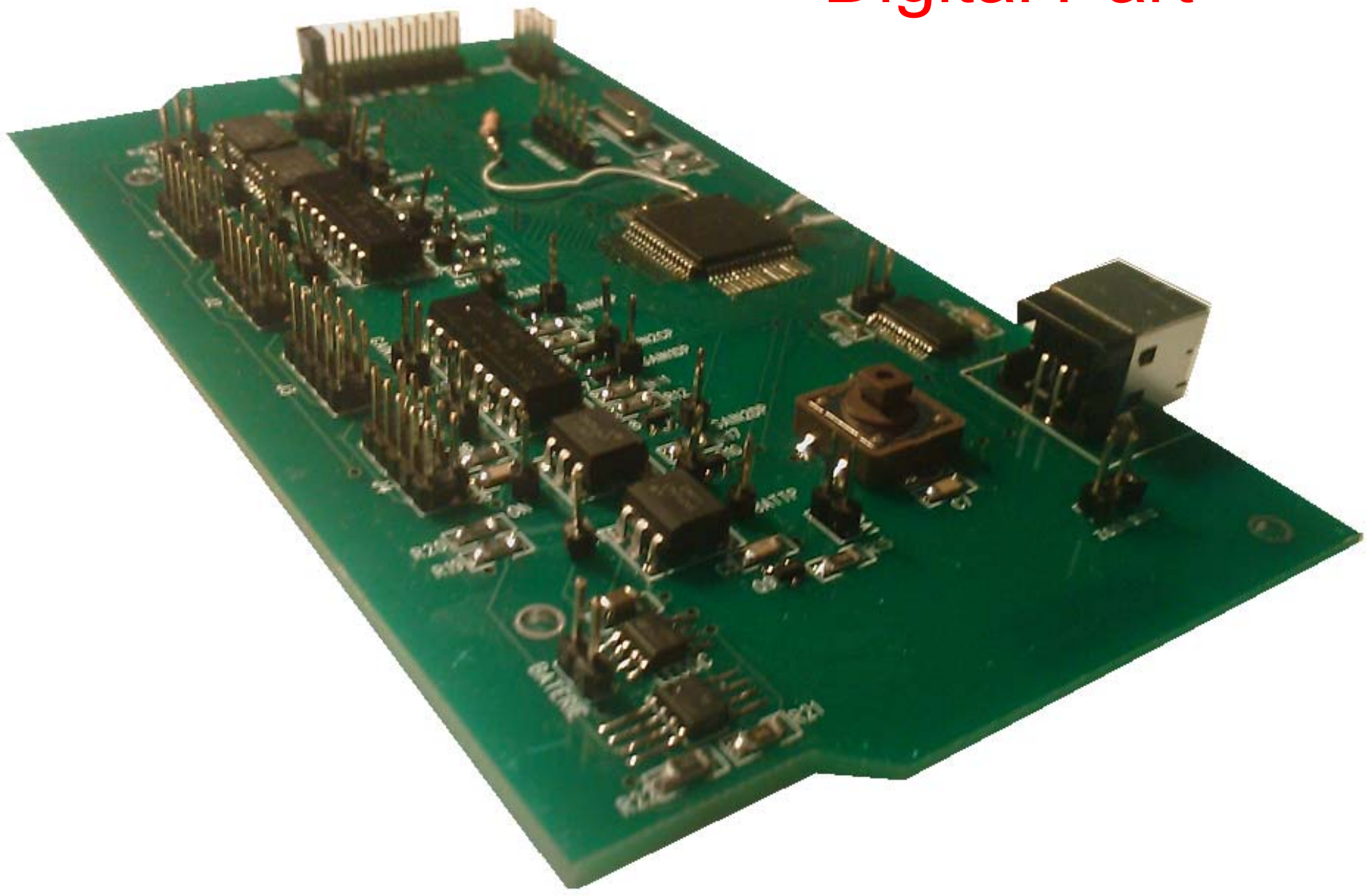

6
5
4
3
2
1
D
C
B
A
3rd stage of amplification
-adjustable: 2 or 20 or 50 [V/V]
-based on bilateral switch CD4066
Total gain selection
-2000 [V/V]
-20000 [V/V]
-50000 [V/V]
Biomedical amplifier

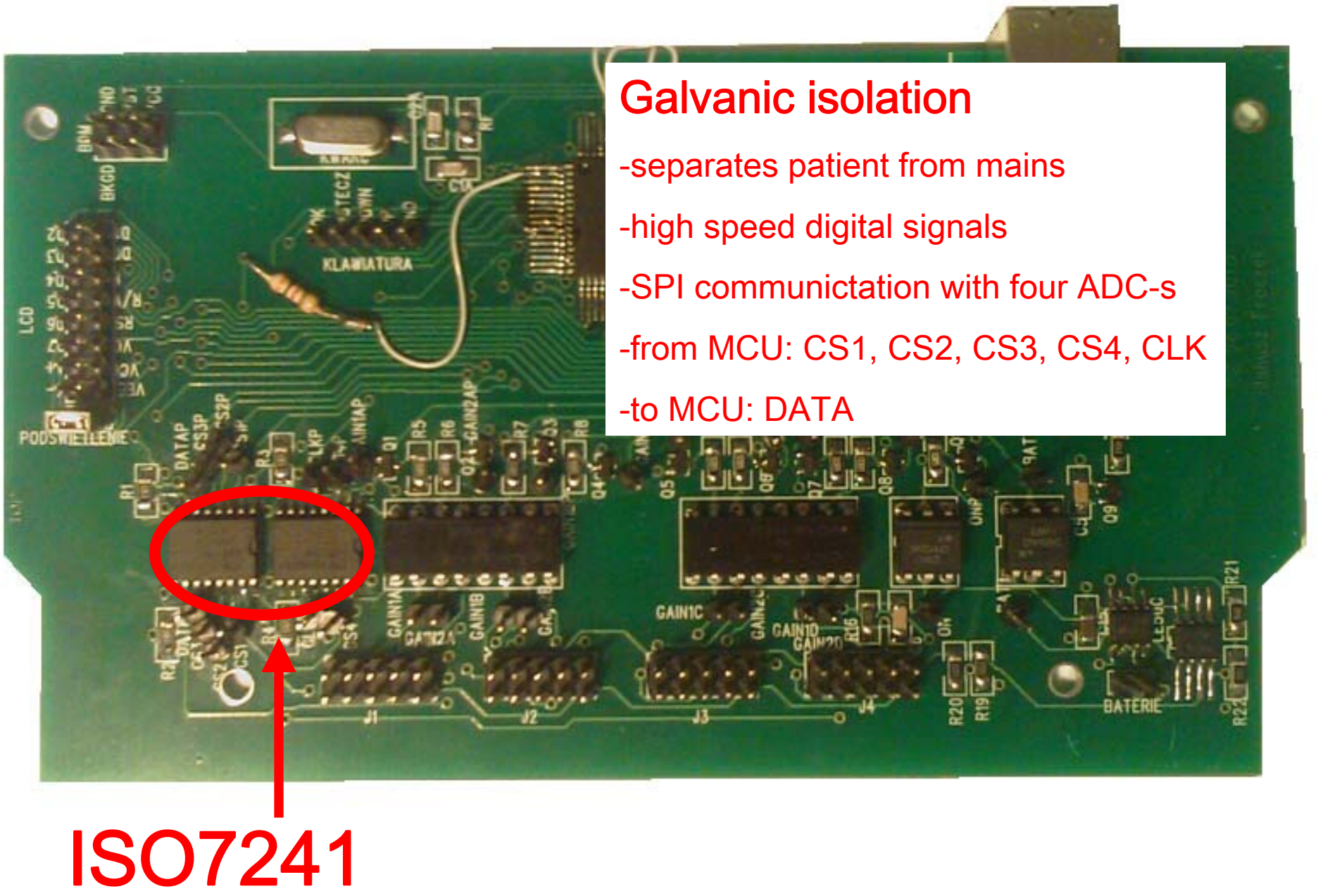

TLC2274
CD4066
VCC
VCC
OUT 3
R31
100k
R32
100k
PT 4
8
VCC
VREF
1
CLK
7
CLK
IN+
2
DATA
6
DOUT
IN-
3
CS
5
CS
VEE
4
MCP3201_SOIC
TLC2274
OUT 1
IN+
3
IN-
2
J
R25
1M
R26
1M
VEE
2
A O/I
A I/O
1
3
B O/I
B I/O
4
9
C O/I
C I/O
8
10
D O/I
D I/O
11
EA
EB
EC
ED
13
5
6
12
CD4066
GAIN1
GAIN2
R27A
56k
R27B
21k
VDD
VDD
R33
100k
R34
100k
C13
100n
C14
100n
VEE
VEE

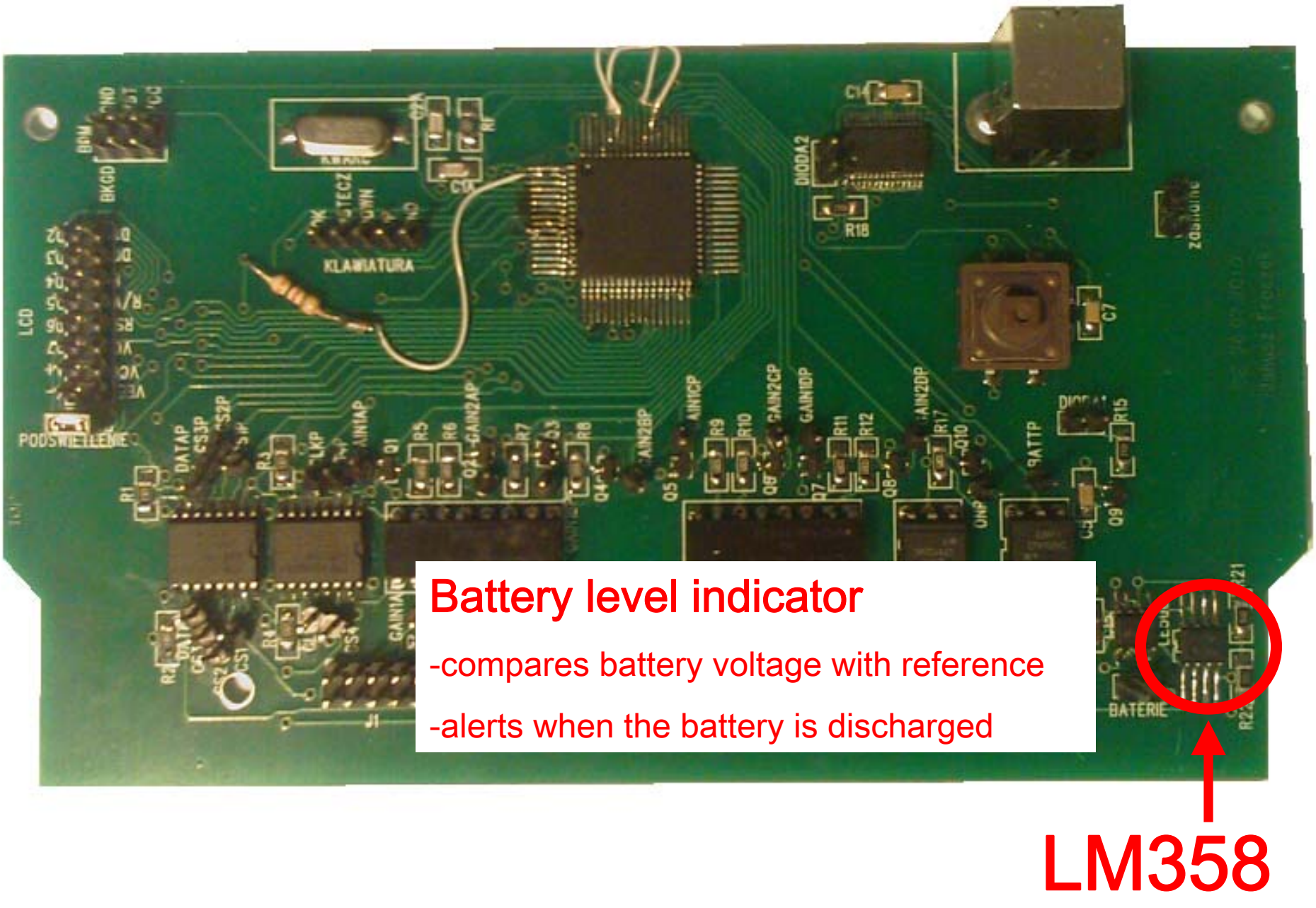


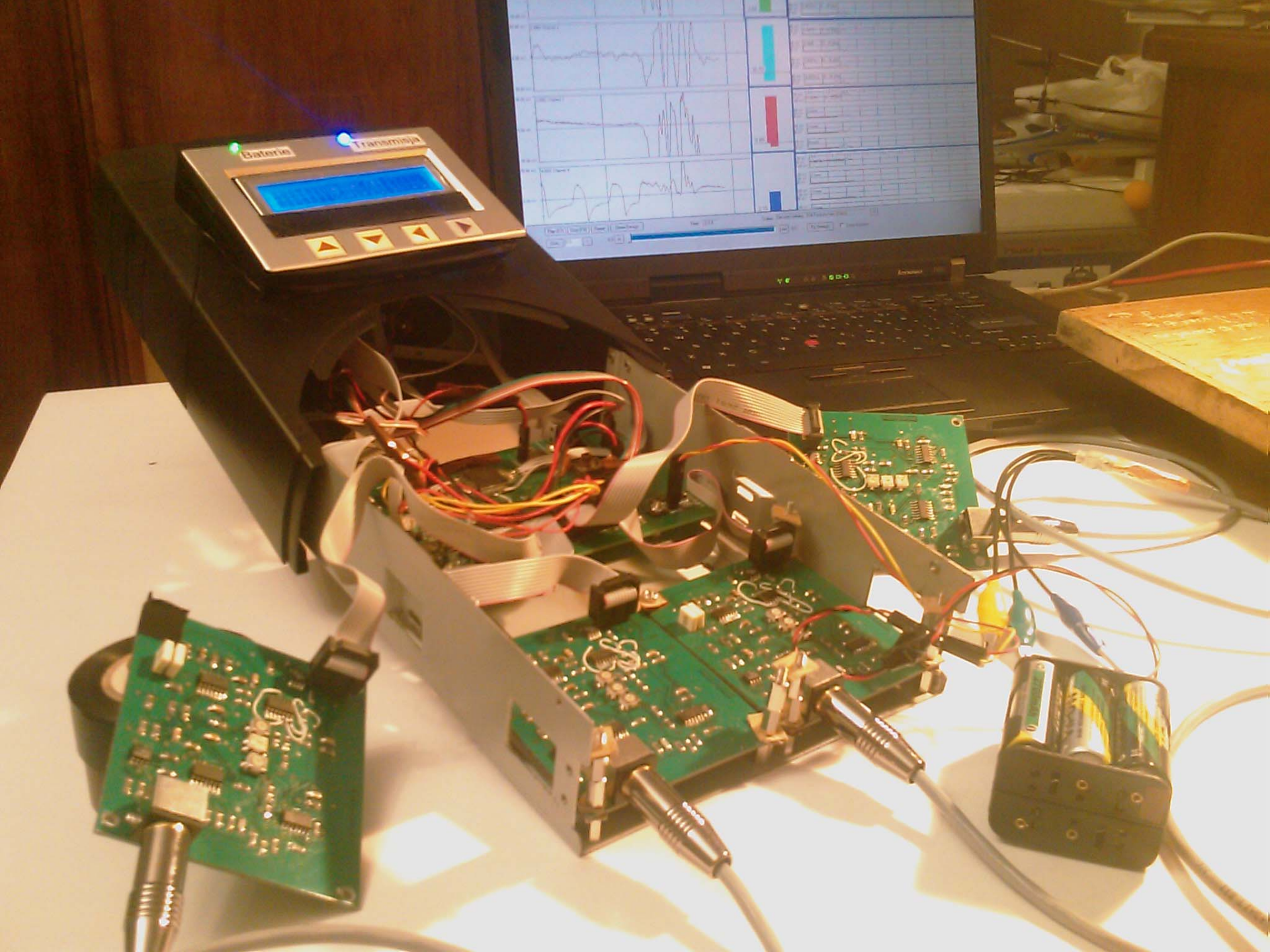


Digital Part

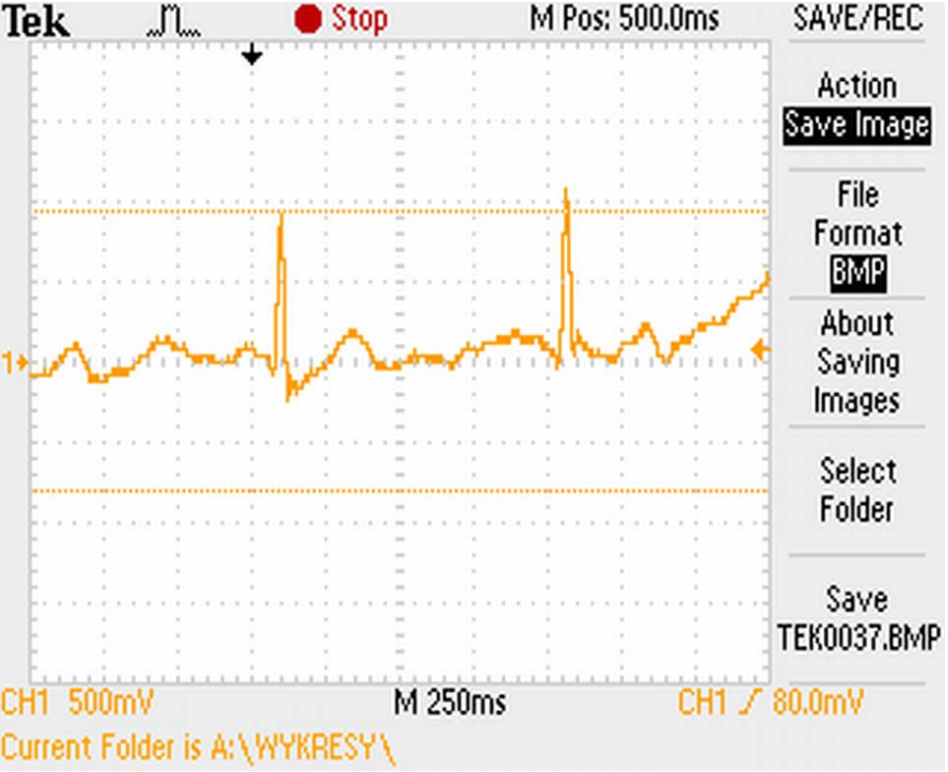


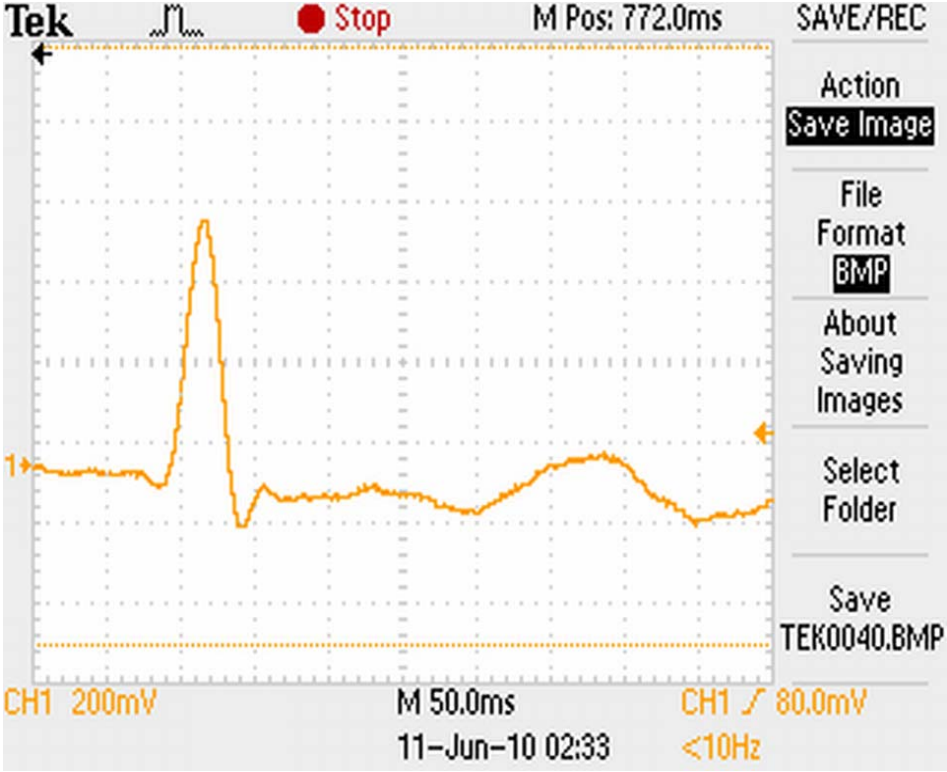

Galvanic isolation
-separates patient from mains
-high speed digital signals
-SPI communictation with four ADC-s
-from MCU: CS1, CS2, CS3, CS4, CLK
-to MCU: DATA
ISO7241
KLAWIATURA
LCD
PODSWIETLENIE
BATERIE
J1
J2
J3
J4


Battery level indicator
-compares battery voltage with reference
-alerts when the battery is discharged
LM358


Baterie
Transmisija

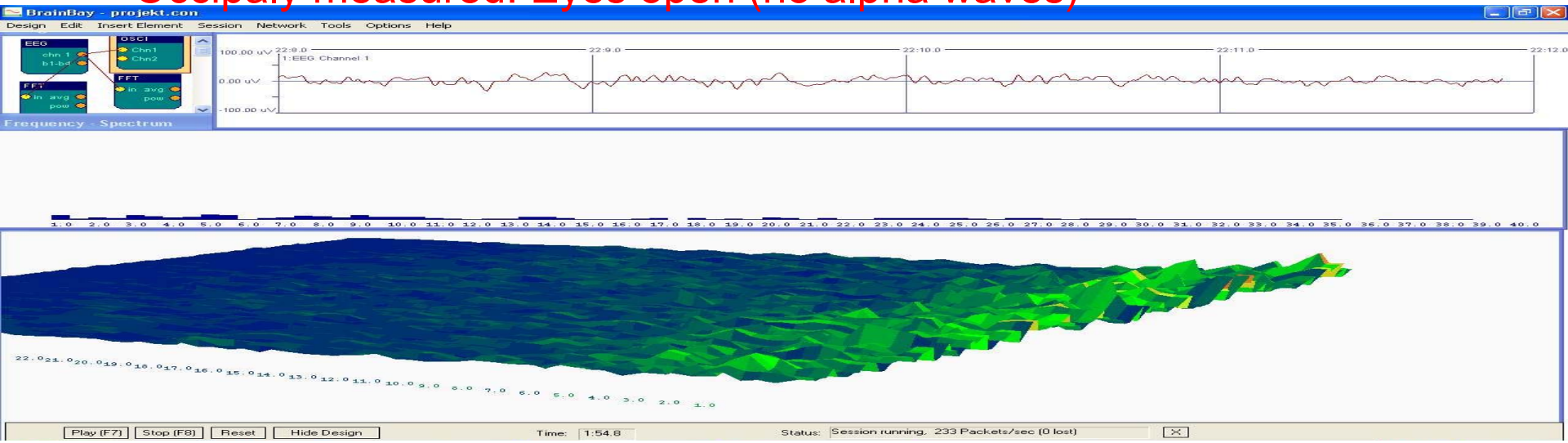
Experimental results - ECG



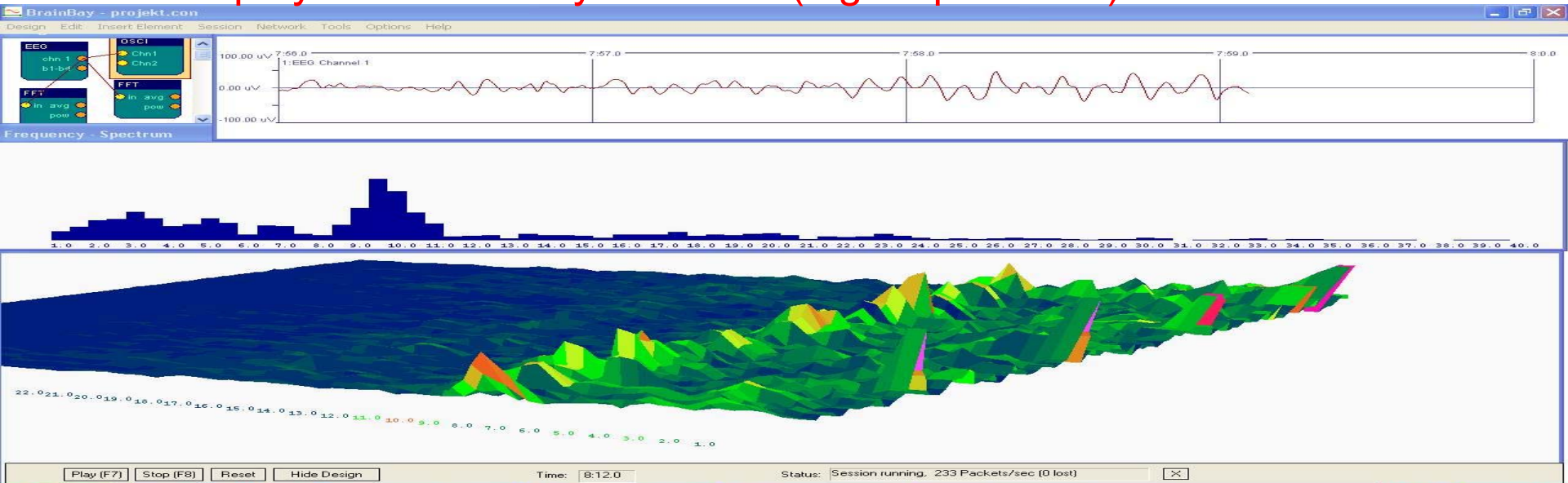


Experimental results - EEG

Occipaly measured: Eyes open (no alpha waves)



Occipaly measured: Eyes closed (high alpha level)



Thanks for your attention!