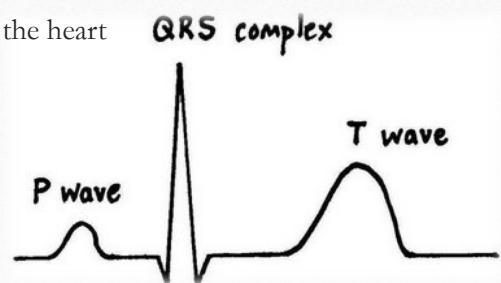
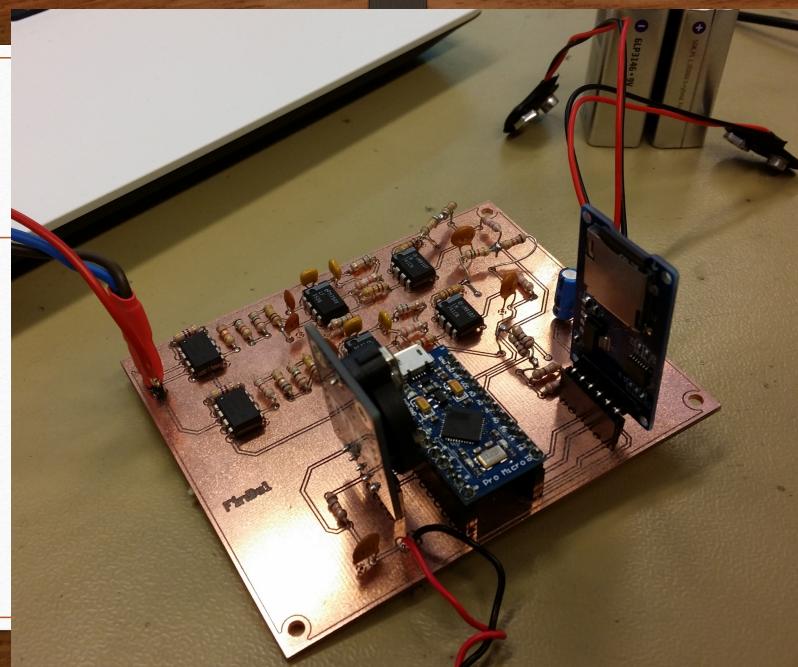
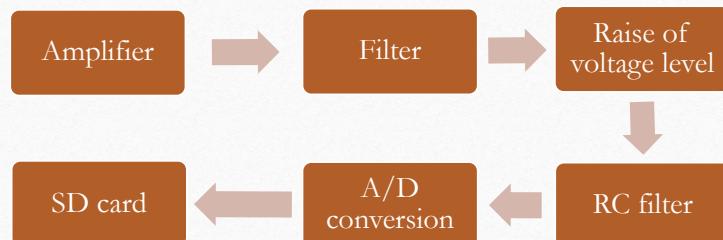


Summary from ECG

- Measurement of electrical impulses of the heart
- Impulse detection using electrodes
- Signal amplification
 - Electrical impulse of heart $\sim 1\text{mV}$
- ECG graphs

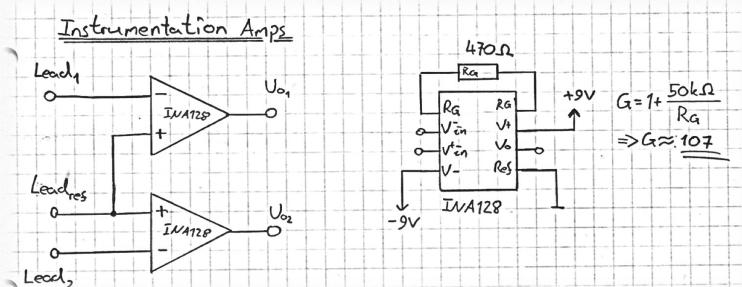


The circuit

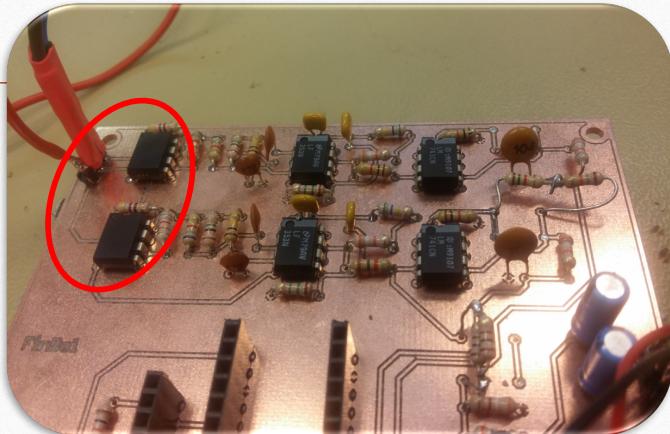


Amplifier

- 2x INA128-instrumentation amplifiers
- Gain(A_u) = ~ 107
- 3x Electrodes
 - Lead(1)
 - Lead(2)
 - Lead(ref)
- 2x ECG signal outputs
 - $U(o_1)$
 - $U(o_2)$

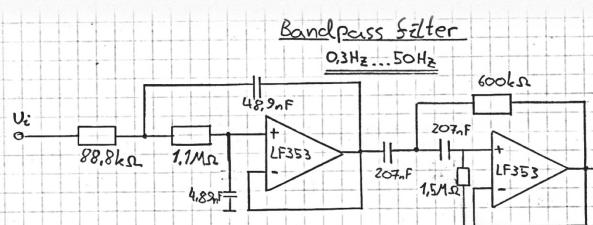


The amplifier on circuit board

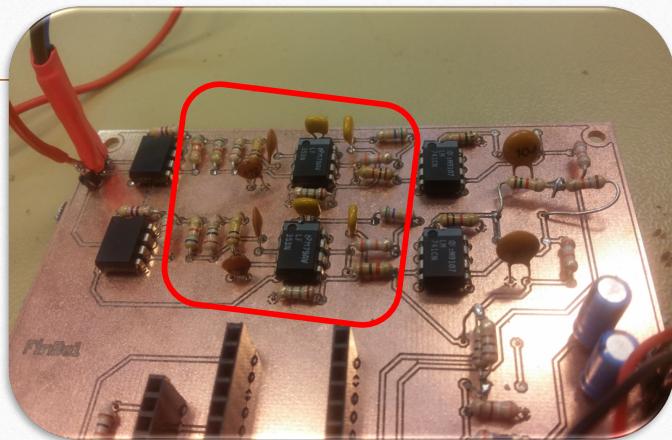


Bandpass filter

- Pass band 0,3Hz ... 50Hz
- LF353N opamp
- First part low rejection
- Second part high rejection

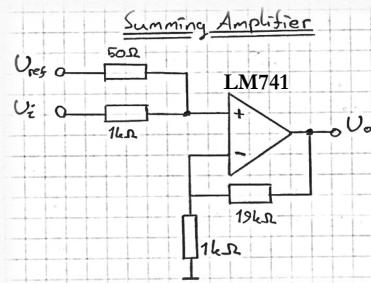


The bandpass filter on circuit board

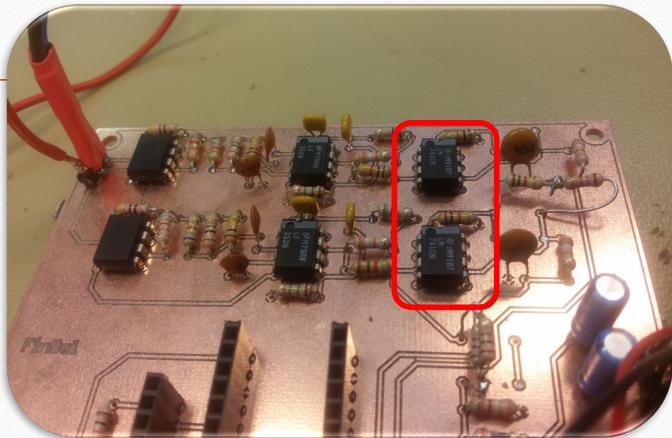


Summing amplifier

- Purpose to raise the voltage level
 - ECG signal >0V
 - Enables the A/D conversion on Arduino MCUs'
 - Also amplifies the signal
- LM741P opamp
- Uref is formed by using a voltage divider
 - $U_{ref} = \sim 105\text{mV}$



Summin amplifier on circuit board



RC lowpass filter

- Removing noise before A/D conversion
- Cut-off frequency > 40,8 Hz
- Phase shift -45°
 - Not important

RC Lowpass Filter

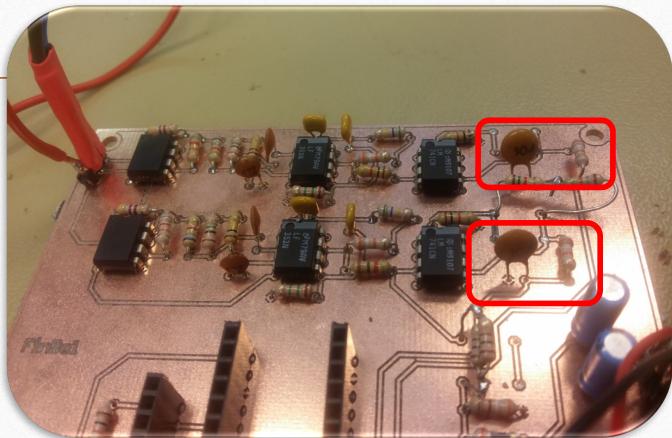
$$f_c = \frac{1}{2\pi RC}$$
$$f_c = \frac{1}{2\pi \cdot 39e3 \Omega \cdot 100e-9 F} \approx 40,8 \text{ Hz}$$

Cut-off freq.:

Phase shift:

$$\varphi = -\tan^{-1}(2\pi f RC)$$
$$\varphi \approx -45^\circ$$

RC lowpass filter on circuit board



Flowchart of firmware (very simplified)

