Instrumentation schematic (block diagram)

| Signal from Instrumentational Amplifier | → CH1 | High Pass Sallen-Key Filter | → | Low Pass Sallen-Key Filter | → | Non-Inverting Amplifier | → **CH2** |

Circuit diagram

CH1

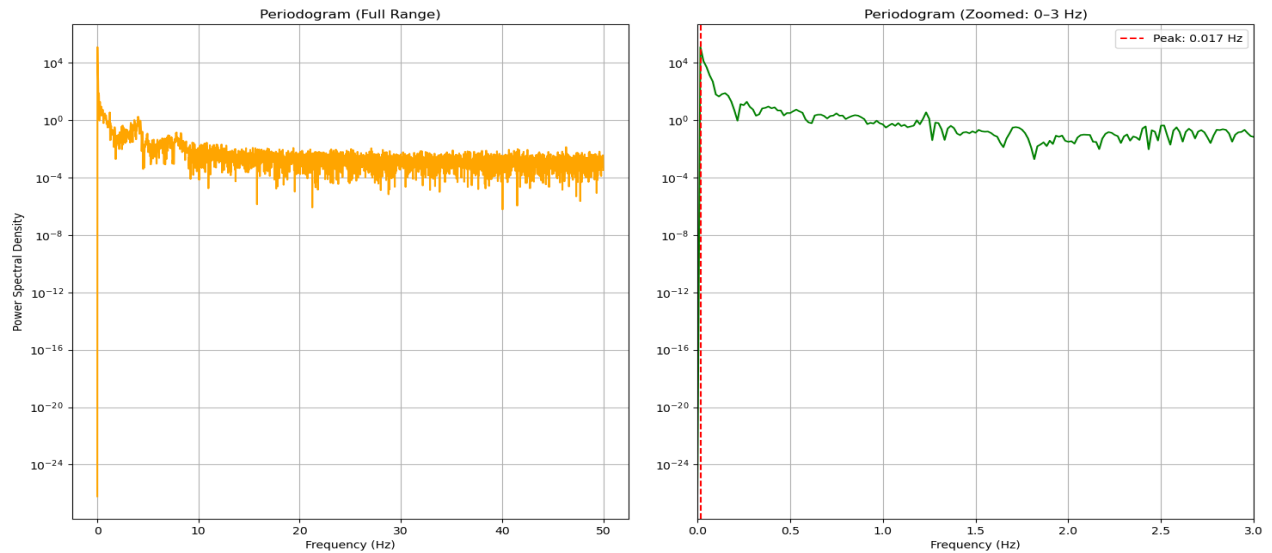330kΩ

1µF

Vin⁻

233Ω INA 121

Vin⁺

Vref

1µF 1µF

33kΩ 33kΩ

1µF

CH2

330kΩ

3.3kΩ

330kΩ

Differential Amplifier

$gain = 1 + \dfrac{50k\Omega}{233\,\Omega}$

$= 215.6$

High-Pass Sallen-Key
$fc = 0.45 Hz$

Low-Pass Sallen-Key
$fc = 4.8 Hz$

Non-Inv Amp
gain = 101

Total Gain = 215.6 × 101 = 21,774.82
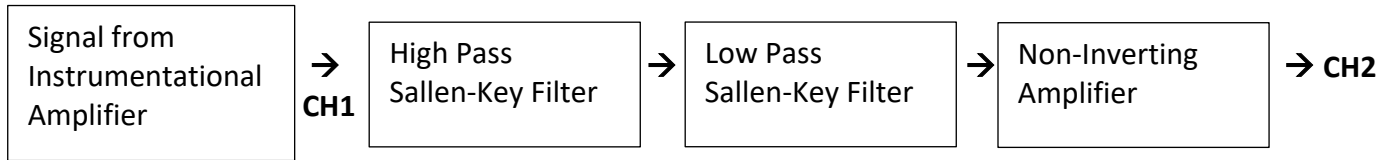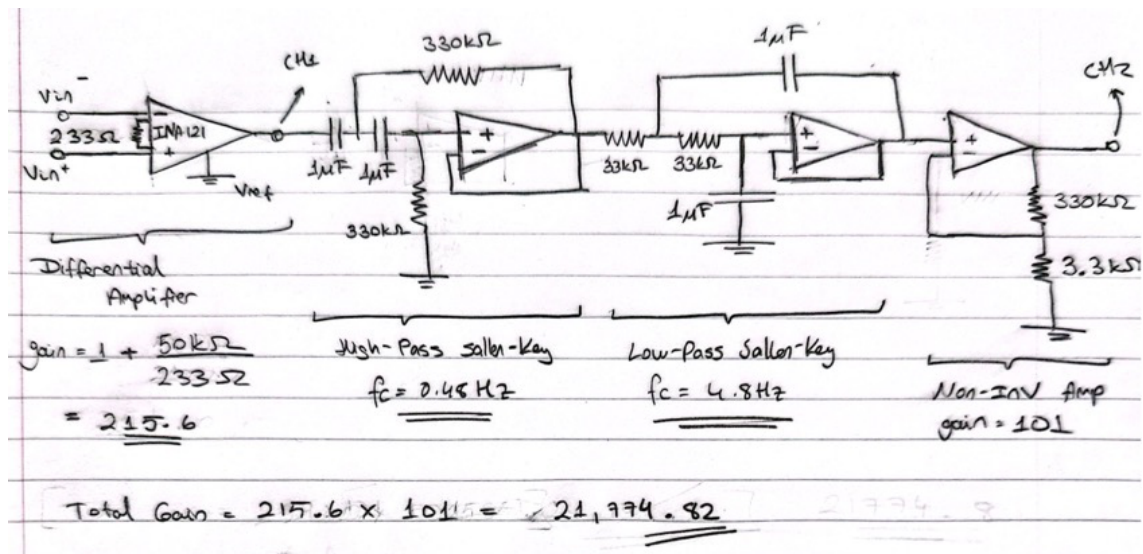
Raw and filtered data (time-domain)

Converted Pressure Signal - Channel 1
Pressure Signal (Ch1) - mmHg

Converted Pressure Signal - Channel 2
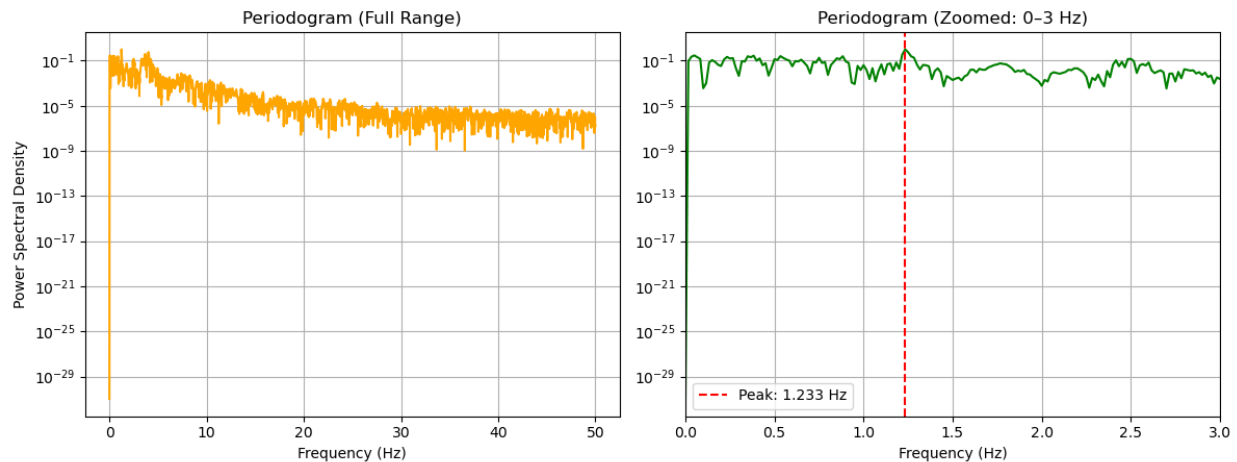Pressure Signal (Ch2) - mmHg
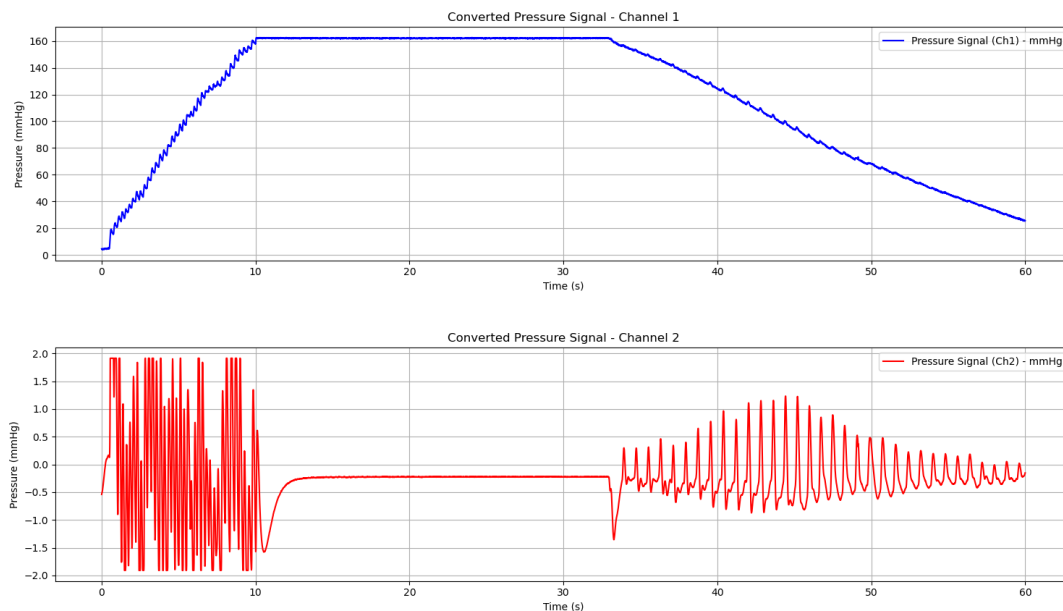
Raw and filtered data (frequency domain, i.e. periodogram)

Untrimmed Unfiltered Data


Untrimmed Filtered Data

Comparing the 2 graphs, there are evident differences. First the most crucial difference is the removal of the constant DC offset. The DC component of the raw data was prominent and causing issues in further data analysis (for example my peak detection algorithm here selected 0 Hz as the peak and therefore hindered my detection of the heart rate). Sallen-Key HPF was able to remove this component. Another difference observed is because of the LPF. In the raw data graph, spectral density is pretty stable after around 10 Hz indicating constant gain however in the filtered data periodogram the density starts falling down showcasing the LPF's functionality in decreasing the gain of the signal above a certain frequency.

'Trimmed' data in time domain
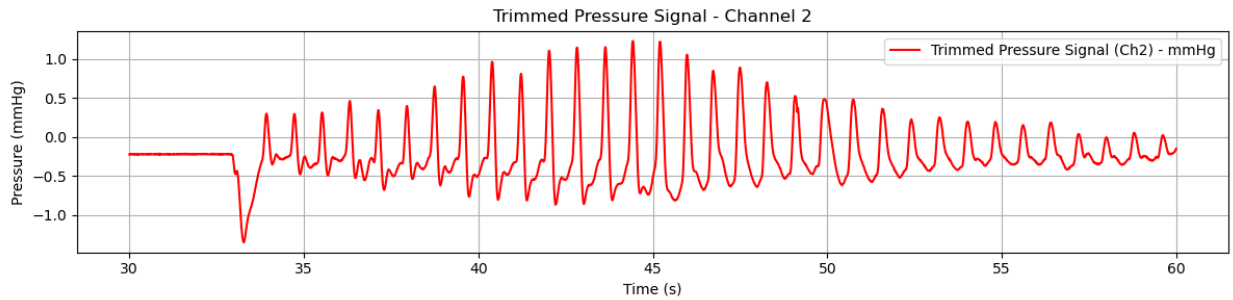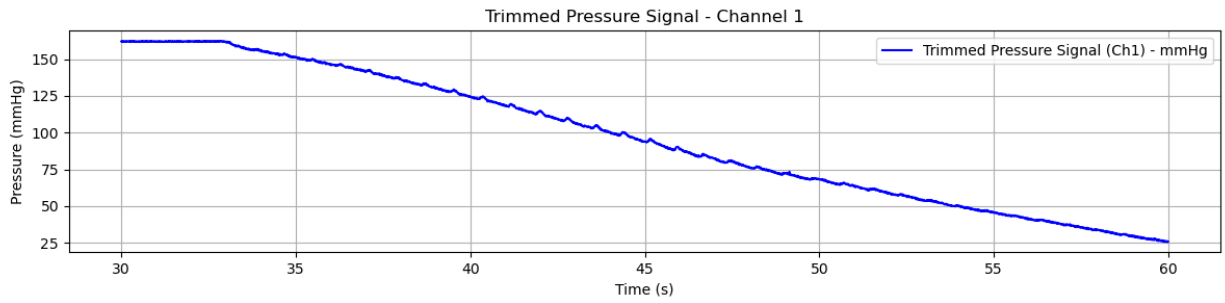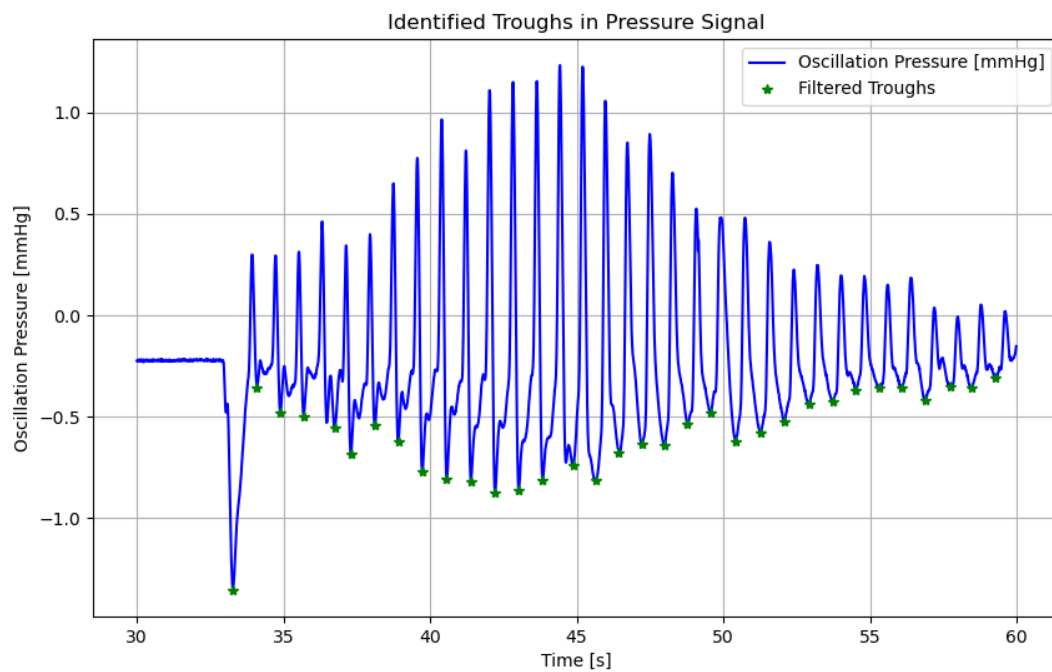

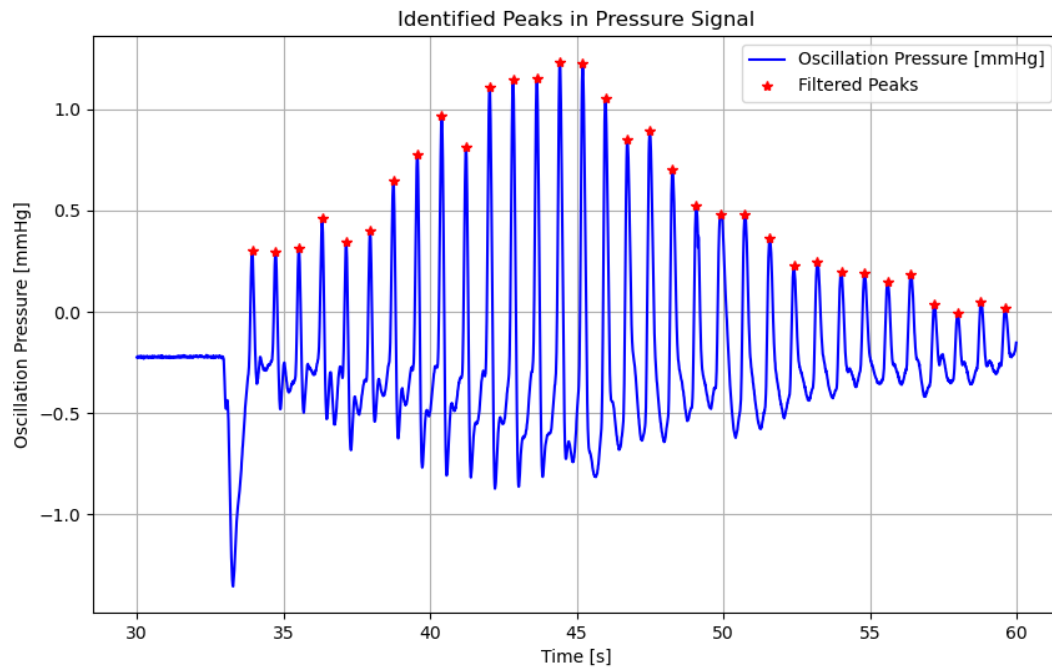## 'Trimmed' data in frequency domain
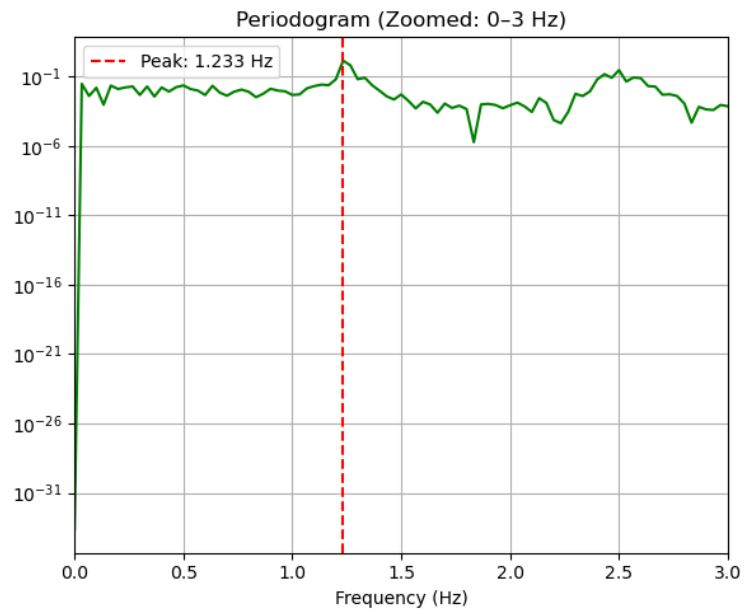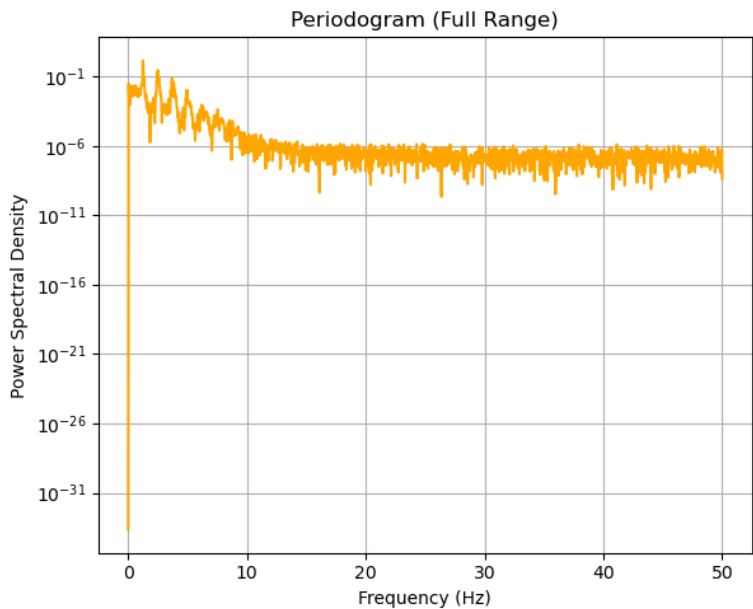
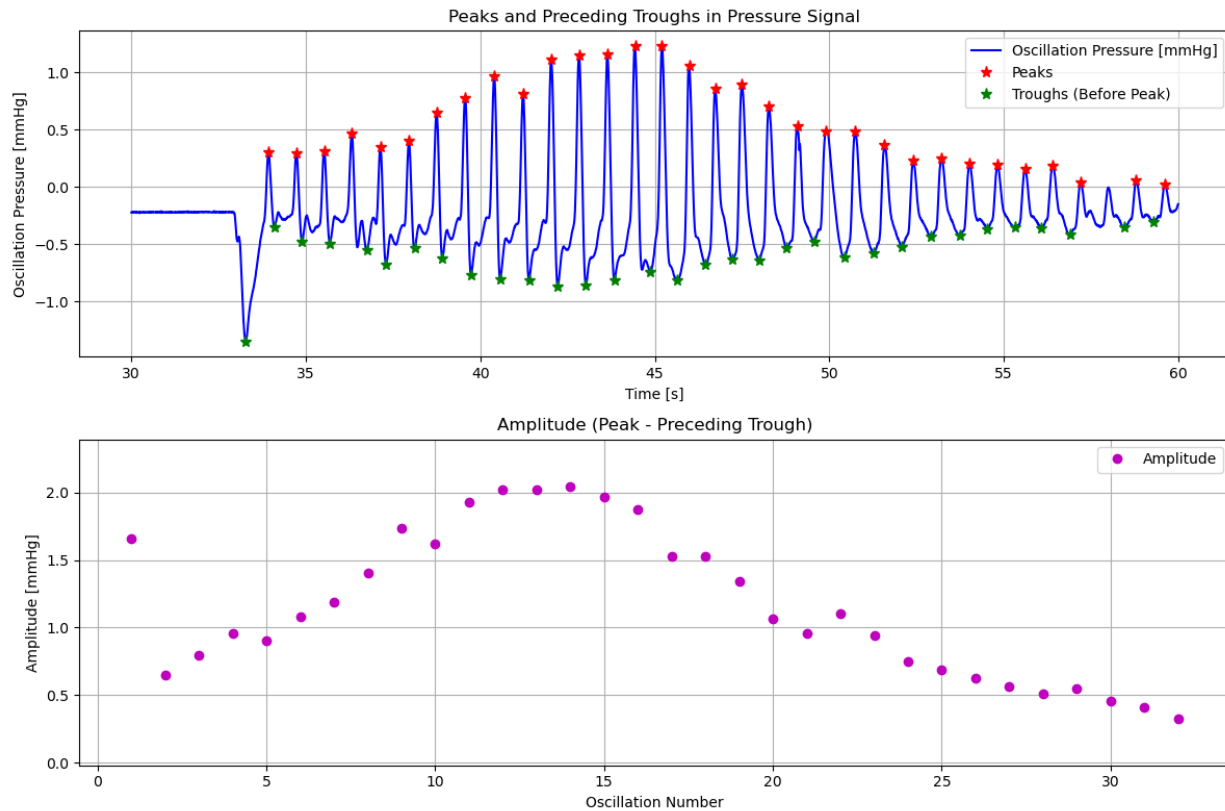**Estimate of the heart rate (found from your code, not just by looking at your plots)**
Peak at 1.233 Hz meaning that HR = 74 bpm

Plot of oscillations with identified peaks and troughs
Can be separate plots with peaks on one and troughs on the other

Plot of peak-to-peak amplitudes

Peaks and Preceding Troughs in Pressure Signal

Amplitude (Peak - Preceding Trough)

Mean Arterial Pressure determination

Also report oscillation number (or time) with largest amplitude

14th peak time = 44.430 s

MAP occurs at index 1443, time = 44.430 s

Estimated Mean Arterial Pressure (MAP): 99.90 mmHg

Systolic Blood Pressure determination

Peak amplitude --> Oscillation 14: Amplitude = 2.05 mmHg

0.55 x 2.05 = 1.1275 mmHg
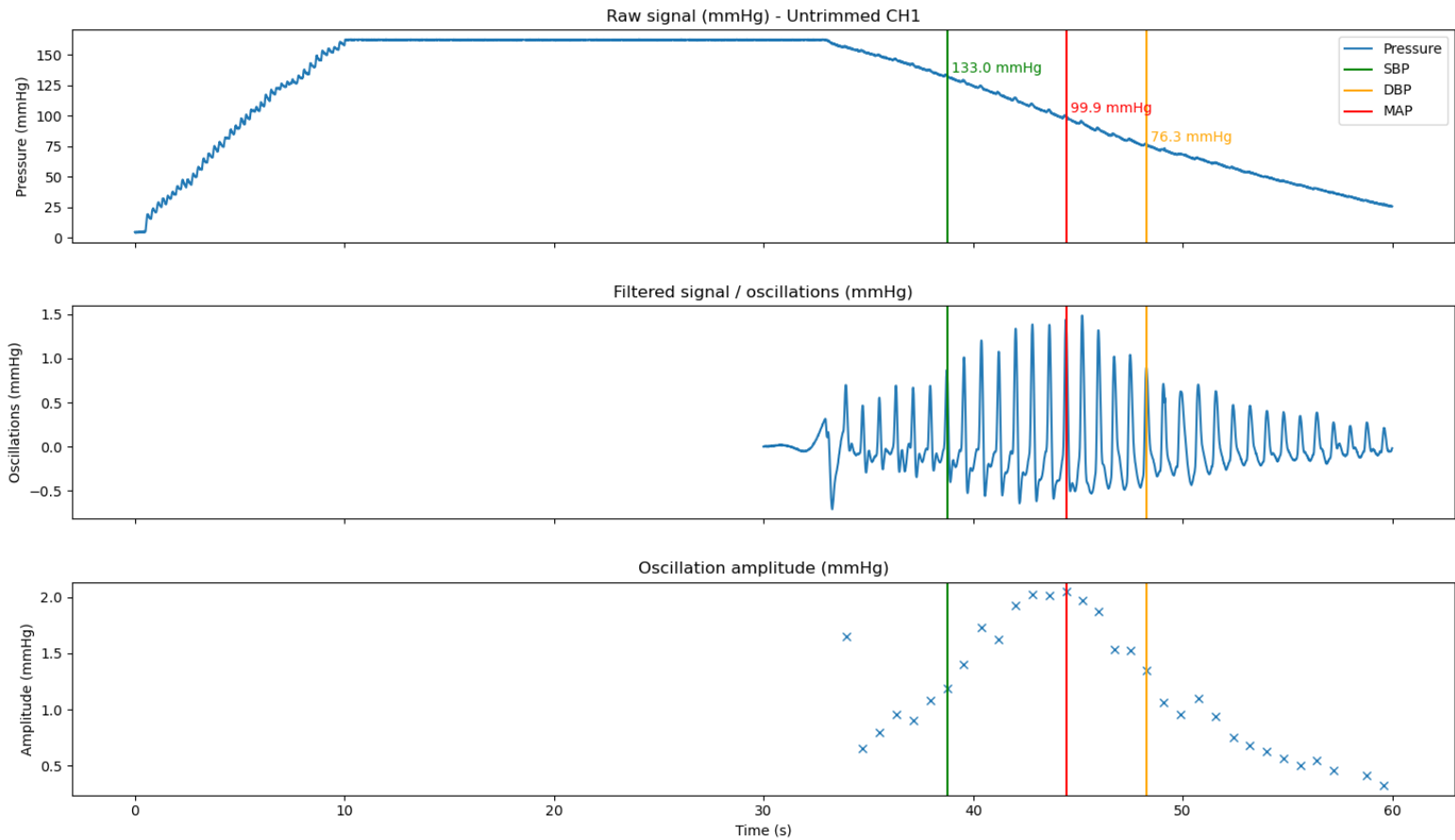
SBP 7th oscillation

Estimated SBP: 133.0 mmHg

Diastolic Blood Pressure determination

0.70 x 2.05 = 1.435 mmHg

DBP 19th oscillation

Estimated DBP: 76.3 mmHg

END RESULT

Final Figure. Full results from a single data set.
Top: Raw signal output from the instrumentation amplifier.
Middle: Signal after high-pass filtering (fc = 0.48 Hz), amplification (gain = 101), and low-pass filtering
(fc = 4.8 Hz).
Bottom: Amplitude of each detected oscillation.
Red bars indicate the Mean Arterial Pressure (MAP) estimate. Green bars represent the Systolic Blood
Pressure and yellow bars represent the Diastolic Blood Pressure estimates.