1. Data

Filename: 'R4.edf R4.xml

Signal:

- EEGsec
- Channel: 3
- Frequency: 125Hz

2. Filter

2.1. baseline remove

- Filter Type: Butterworth High-pass Filter
- Parameters:
  - Order: 4
  - Cutoff frequency: 0.5 Hz
  - Zero-phase filtering (filtfilt)
- Rationale:
  - Butterworth filter chosen for its maximally flat frequency response
  - 0.5 Hz preserves delta waves (0.5-4 Hz) while removing DC and very slow drifts
  - Order 4 provides good transition steepness without excessive ringing
  - filtfilt eliminates phase distortion

2.2. muscle noise remove

- Filter Type: Butterworth Low-pass Filter
- Parameters:
  - Order: 4
  - Cutoff frequency: 35 Hz
  - Zero-phase filtering (filtfilt)
- Rationale:
  - Preserves main EEG rhythms (up to beta band, 13-30 Hz)
  - Removes high-frequency muscle artifacts (>35 Hz)
  - Order 4 balances between stopband attenuation and minimal signal distortion
  - Butterworth characteristics prevent ripples in passband

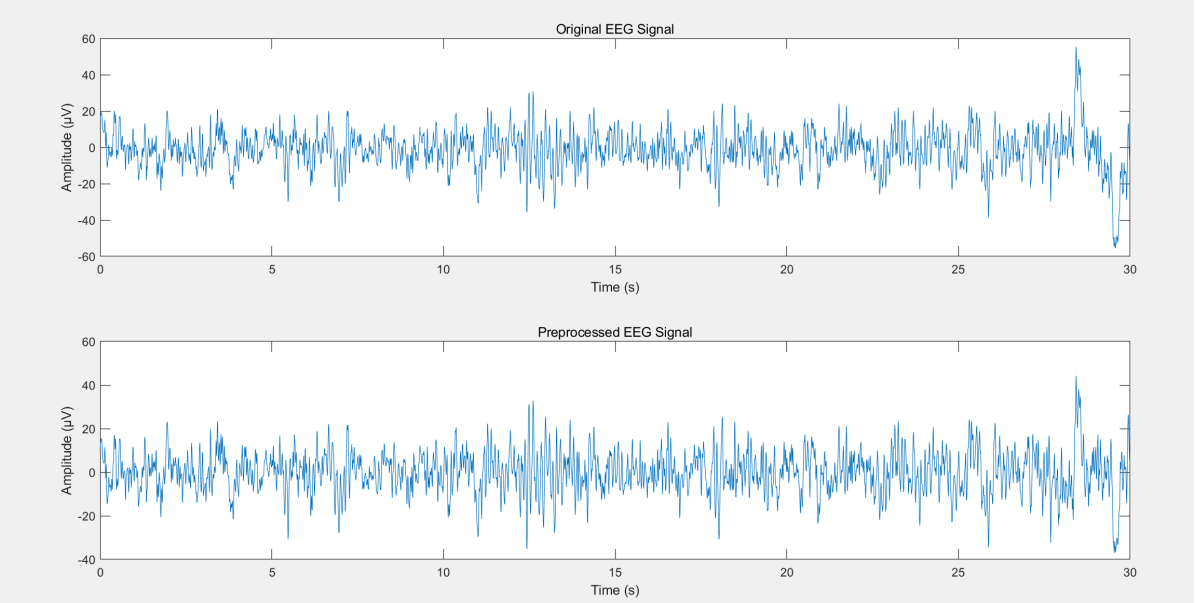
2.3. powerline remove

- Filter Type: Butterworth Band-stop Filter
- Parameters:
  - Order: 2

    - Center frequency: 50 Hz (or 60 Hz)
    - Bandwidth: 2 Hz
    - Zero-phase filtering (filtfilt)
- Rationale:
    - Band-stop filter specifically targets power line interference
    - Lower order (2) minimizes distortion around the stop band
    - 2 Hz bandwidth accounts for power line frequency fluctuations
    - Butterworth response prevents distortion in adjacent frequencies

3. Result

3.1. Signal



Signal Amplitude and Range:

- Original signal: approximately ±40-50 μV with some peaks reaching ±60 μV
- Preprocessed signal: slightly reduced amplitude range of about ±35-40 μV
- This reduction suggests successful removal of noise components while maintaining the main EEG features

Baseline Stability:

- Original signal shows some slow variations in the baseline
- Preprocessed signal appears more stable around zero
- The high-pass filter (0.5 Hz) has effectively removed baseline drift

Signal Morphology:

- The overall shape and key features of the signal are well preserved
- Important EEG patterns remain intact
- No visible distortion or phase shifts (thanks to zero-phase filtering)

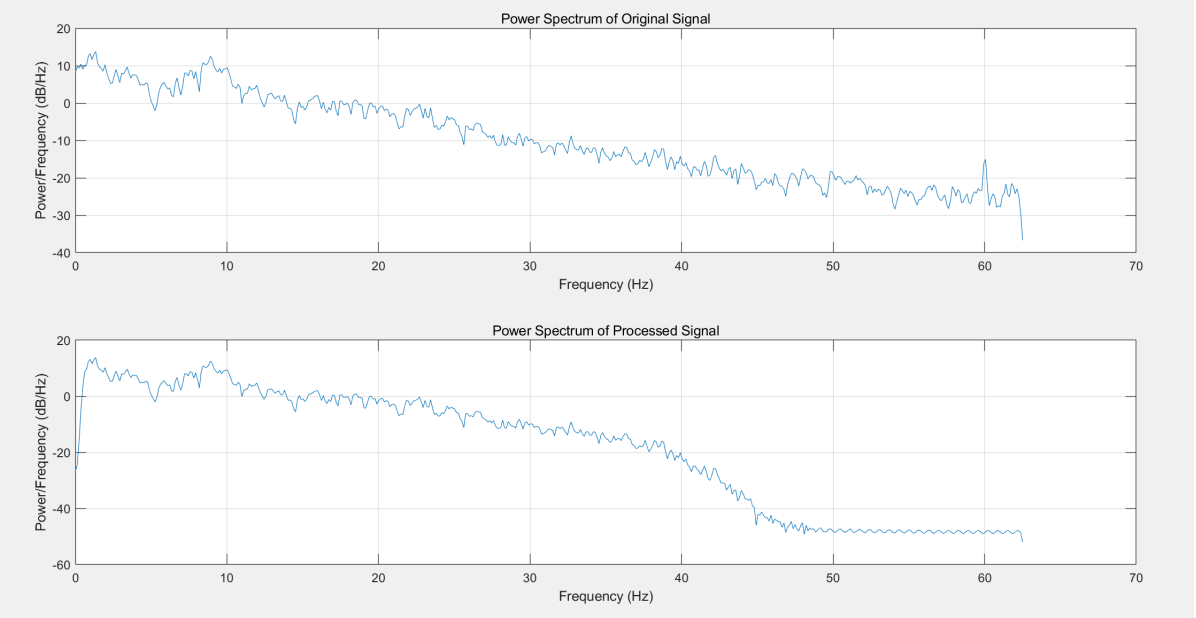
Noise Reduction:

- High-frequency noise (>35 Hz) appears reduced
- The signal looks cleaner but not over-smoothed
- Sharp transients are preserved, indicating good filter design

Time Domain Features:

- Temporal relationships between events are maintained
- No obvious edge effects at the beginning or end of the epoch
- The signal maintains its natural variability

3.2. Power Spectrum



Low Frequency Range (0.5-4 Hz, Delta band):

- Original: Strong power presence
- Processed: Very low frequencies (<0.5 Hz) are attenuated by high-pass filter
- Delta band activity is well preserved
- Baseline drift removal is effective

Main EEG Frequency Bands:

- Delta (0.5-4 Hz): Preserved, showing strong power
- Theta (4-8 Hz): Maintained without significant attenuation
- Alpha (8-13 Hz): Well preserved
- Beta (13-30 Hz): Maintained with natural power decline

High Frequency Components:

- Original: Gradual power decrease up to 60 Hz with visible 50 Hz power line interference
- Processed:
    - Sharp roll-off after 35 Hz due to low-pass filter
    - 50 Hz power line interference effectively removed
    - High-frequency noise (>35 Hz) significantly reduced

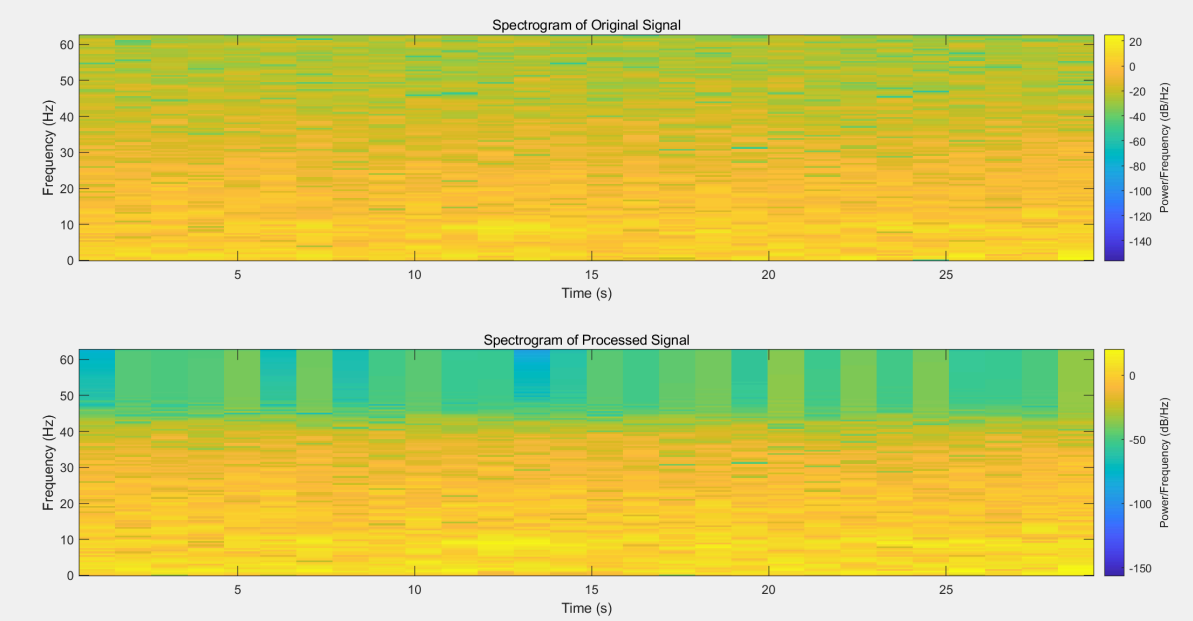
Filter Effects:

- High-pass filter (0.5 Hz): Clear removal of very low frequency components
- Low-pass filter (35 Hz): Creates clear attenuation above 35 Hz
- Band-stop filter (50 Hz): Successfully removes power line interference
- Overall shape of spectrum in physiological bands (0.5-35 Hz) is well preserved

Notable Improvements:

- Cleaner spectrum with reduced noise
- Maintained physiologically relevant frequencies
- Effective noise removal without distorting important EEG bands
- Smooth transition at filter cutoff frequencies

3.3. Spectrogram



Frequency Band Distribution:

- Delta (0.5-4 Hz): Strong power (bright yellow) maintained in both signals
- Theta (4-8 Hz): Well preserved, showing consistent power
- Alpha (8-13 Hz): Power structure maintained
- Beta (13-30 Hz): Moderate power preserved
- Higher frequencies (>35 Hz): Significantly attenuated in processed signal

Filter Effects:

- Low frequency components (<0.5 Hz):
  - High-pass filter effect visible, removing baseline drift
  - No significant distortion of delta band activity
- High frequency region (>35 Hz):
  - Original: Shows consistent power up to 60 Hz
  - Processed: Clear attenuation above 35 Hz (visible color change from yellow/green to blue)

- 50 Hz power line interference:
    - Original: Visible as a consistent band around 50 Hz
    - Processed: Successfully removed, shown by blue/green coloring in that region

Temporal Characteristics:

- Time-varying patterns well preserved in physiological bands (0.5-35 Hz)
- No visible edge effects or temporal distortions
- Signal dynamics maintained across the 30-second epoch