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ASSIGNMENT 2

Spectral Analysis for EEG signal

Assignment
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ABSTRACT

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The content of this report demonstrates the work has been done for Assignment 2 of the course BBT-HTI-501 Processing of Biosignals.

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1. INTRODUCTION

In this project, EEG signals from two sources (PhysioNet data bank and self-measured) were investigated using spectral analysis method. The goal is to apply different variations of time-frequency domain parameters and assess the corresponding results.

2. METHOD

There are two main tasks implemented in this assignment:

- Signal acquisition: obtain the signal for the analysis phase, get to know how the signal was measured and note the metadata of the signal.
- Signal (spectral) analysis: obtain the Power Spectral Density (PSD) and spectrogram of the signal on multiple parameter settings.

2.1 Signal acquisition

In the first option, signal can be download from PhysioNet EEG database and read with provided function readedf_EX1.m. Along with other metadata, the provided functions return the EEG measurement Fpz-Cz with the sampling frequency of 100 Hz.

In the second option, signal was also measured with the BIOPAC EEG equipment at HeAT lab (SM502). The instruction can be found in the EEG Lab 03 document. There are three channel V+, V- and GND whose locations can be described in the figure below (the electrodes used in our measurement were of a different type but operated on the same locations).

Figure 1 Electrodes locations [1]

Other parts involved in the measurement can be list as: MP36 hardware, BSL 4 software and SS2L Electrode Lead Set. After the calibrating process, the participant was asked to perform different state, namely: eyes closure/opening, blinking, arithmetic task and reading to affect the EEG signals.

2.2 Signal analysis

In the beginning of the analysis phase, the obtained signals were always plotted with the proper time scale to get an overview of the data and spot the obvious error from the previous phase. The overview of both EEGs can be seen from figure 2 and 3.

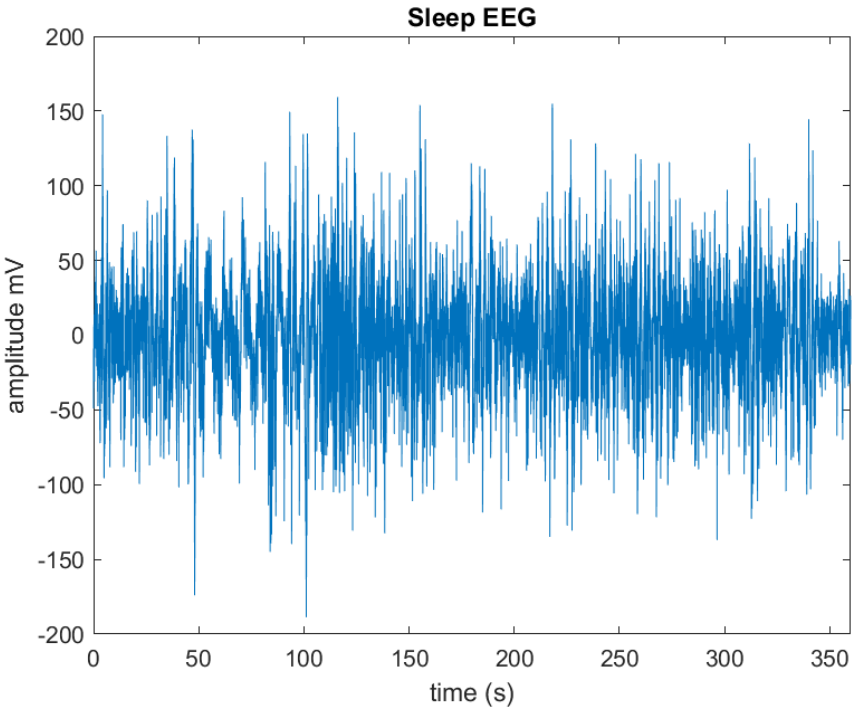

Figure 2 Sleep EEG overview

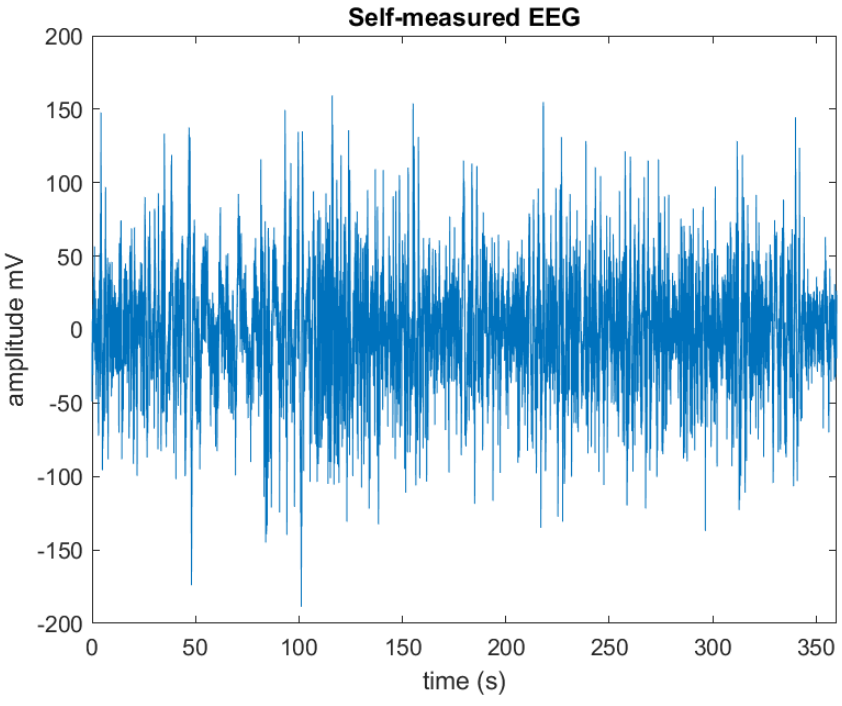

Figure 3 Self-measured EEG overview

There are two main functions (given in MATLABA toolbox) used for the analysis phase: pwelch (to obtain the PSD) and spectrogram (for time-frequency domain analysis). There are three parameters in both functions that will be alternated to investigate their effect on the corresponding results: window length, overlap and number of DFT points.

Each parameter was analyzed by increase or decrease their value while keeping the other two unchanged. For PSD of the sleep EEG, functions to alternate and plot the processed signals in the same plot were made for the ease of comparison. For spectrograms, overlaying two spectrograms may worsen the observability hence results of two distinguished values were placed next to each other for comparison. Explanatory legends and titles were added to provide the context of each experiment.

3. RESULTS AND DISCUSSION

The observed effects of the parameter settings on both PSDs and spectrograms can be combined and summarized as follow:

- Window length: the smaller window duration/number of samples in results on smoother/ high frequency resolution representation while decreasing the temporal resolution as discussed in [2]. To be more specific, the higher value of window length gives us jittery line which was also composed of less points in the PSD. In the case of spectrograms, the higher value of window length results in the blocky look while lower value of window length gives a smoother transition (observed via colour code)
- Overlap: increasing the value of overlaps gives us more data point and higher resolution in the time domain. The effect of overlap on the frequency domain in this experiment is not significant.
- Number of DFT points: The more DFT points used in the PSD/Spectrogram, the higher resolution in the frequency domain one will obtain. This perk, however, comes with more expensive computational power.

The figures created in the experiment are attached in the appendix.

About the stationarity of the signal, the self-measured EEG in figure 4 can be used to support the explanation.

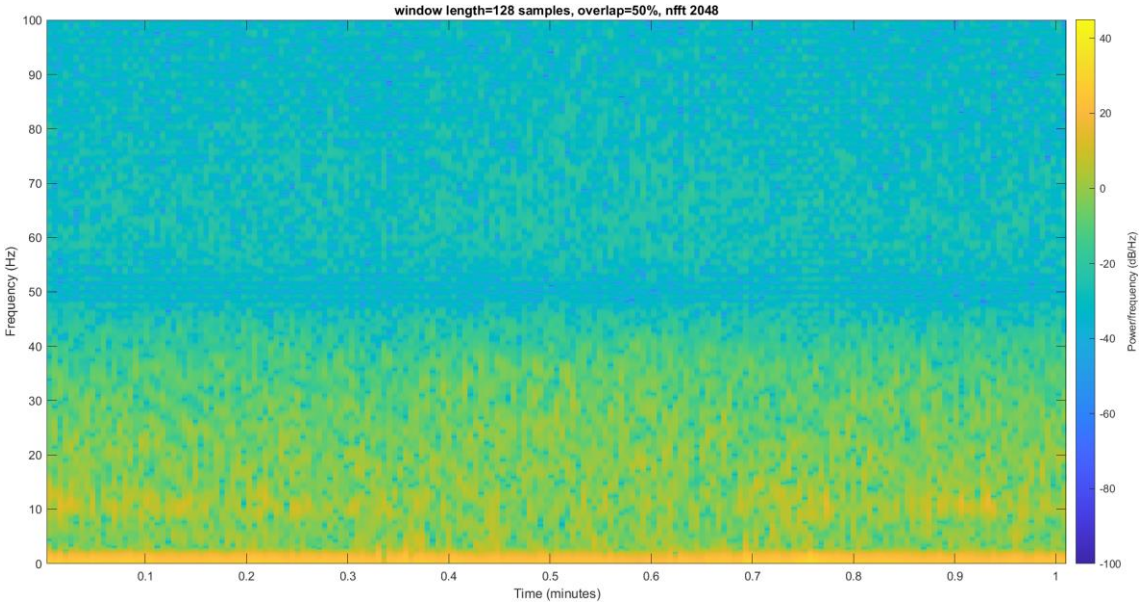

Figure 4 Measured EEG (1)

From figure 4, the frequency component of the EEG was not constant over time. The power at 10 Hz was detected only on some interval (aligned with the eye-closure periods) along the time axis. There was no observable time-period/pattern that can be distinguished from the EEG. Hence from the preliminary spectral analysis, one can conclude that this EEG signal is non-stationary.

4. CONCLUSION

For spectral analysis, the selection of parameter setting (window length, overlap and number of DFT points) does affect the representational result of both the PSD and the spectrogram. The resolution in time/frequency domain and the computational complexity should be put into consideration in the analysis process.

EEG signal in this assignment was observed to be a non-stationary signal in the spectrogram.

REFERENCES

1. Richard Pflanzer, Ph. D. Biopac student lab Lesson 3 – Electroencephalography l procedure.
2. Rangaraj M. Rangayyan PhD, Biomedical Signal Analysis. Wiley, 2015

APPENDIX

PSD experiment

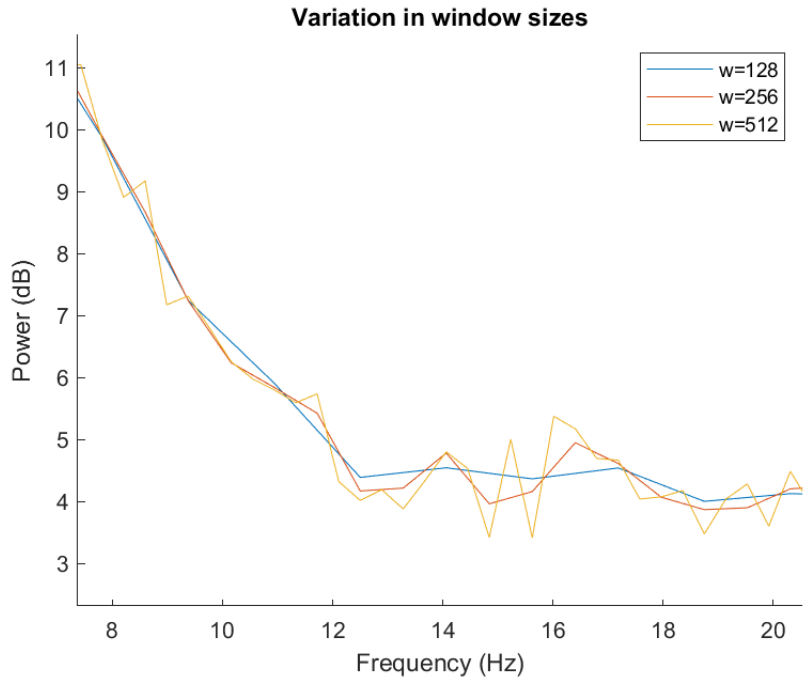

Figure 5 Sleep EEG - window size

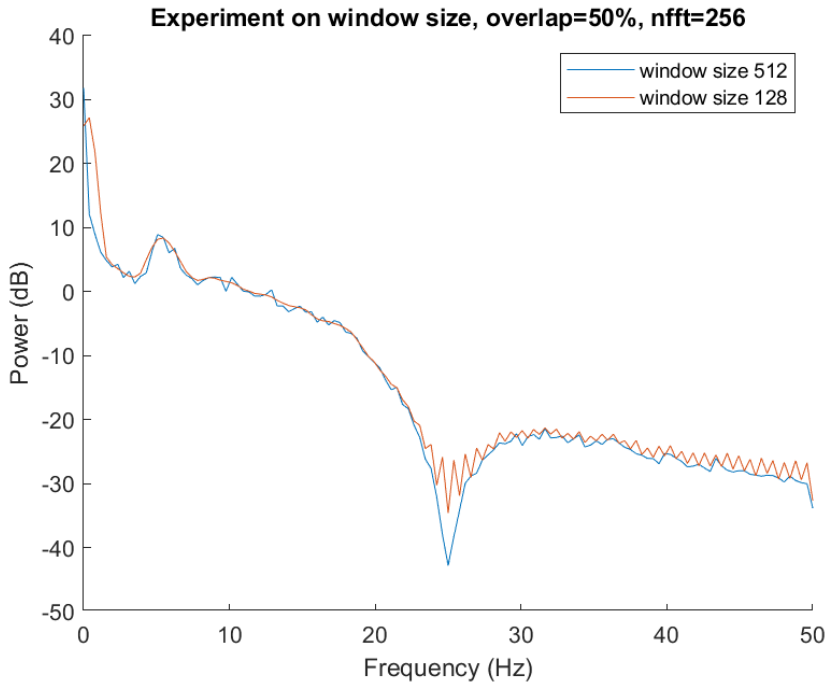

Figure 6 Self-measure EEG - window size

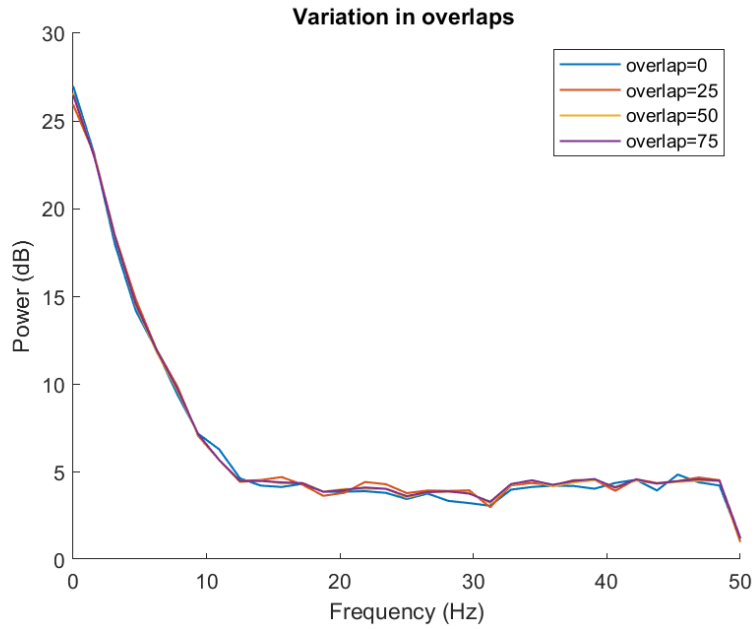

Figure 7 Sleep EEG – overlap

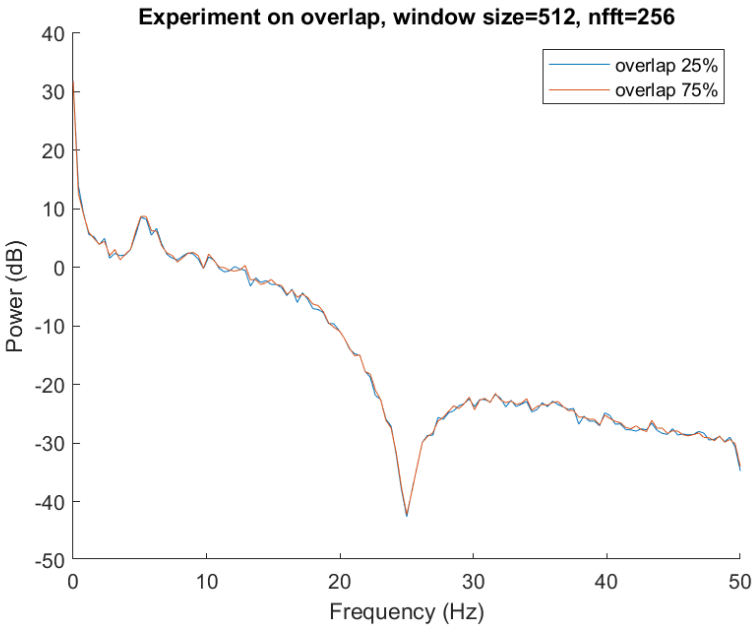

Figure 8 Self-measured EEG – overlap

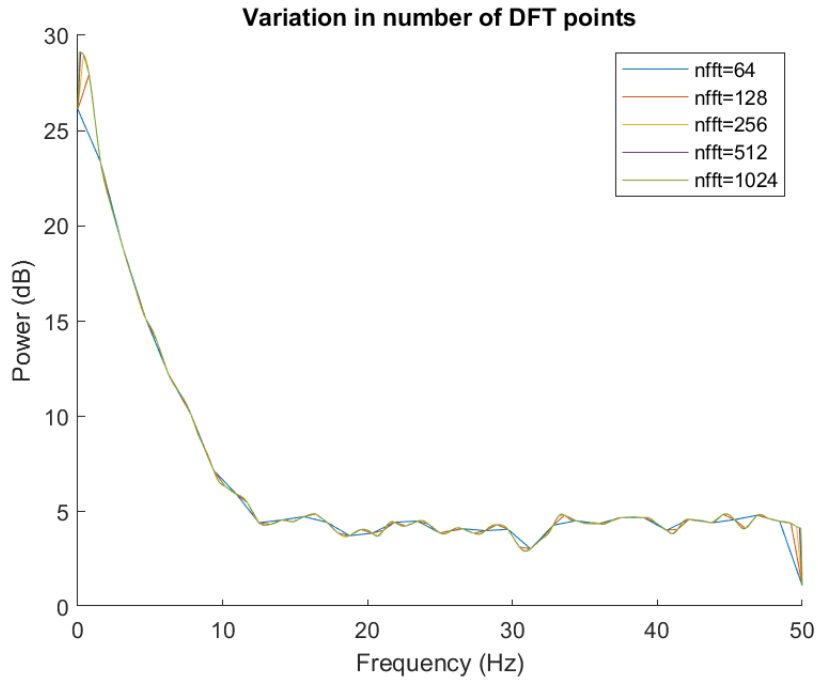

Figure 9 Sleep EEG - DFT points

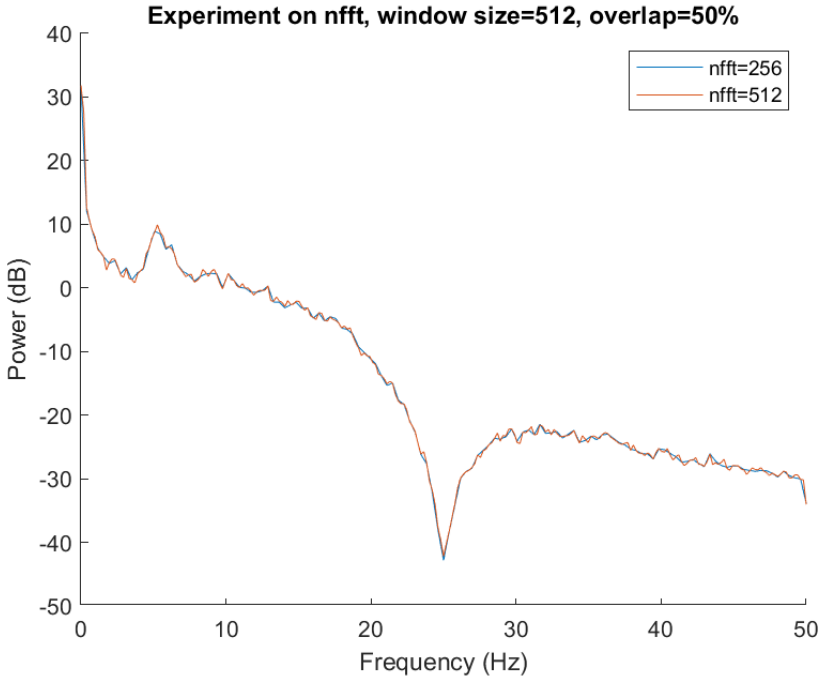

Figure 10 Self-measured EEG - DFT points

Spectrogram experiment

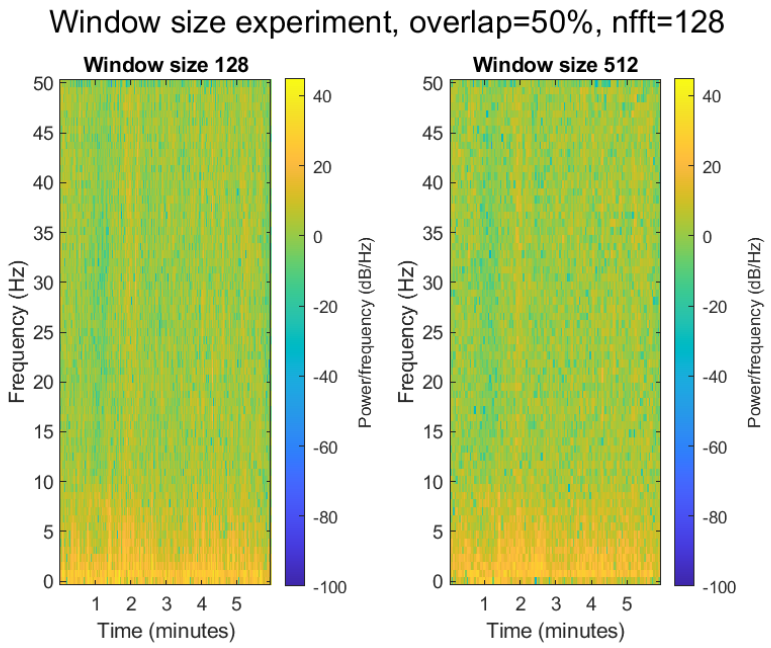

Figure 11 Sleep EEG - window length

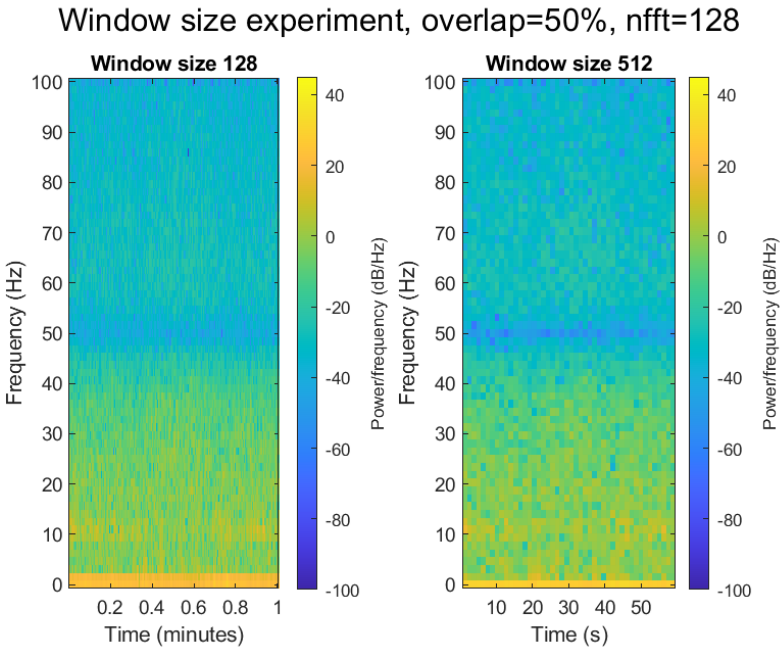

Figure 12 Self-measured - window length

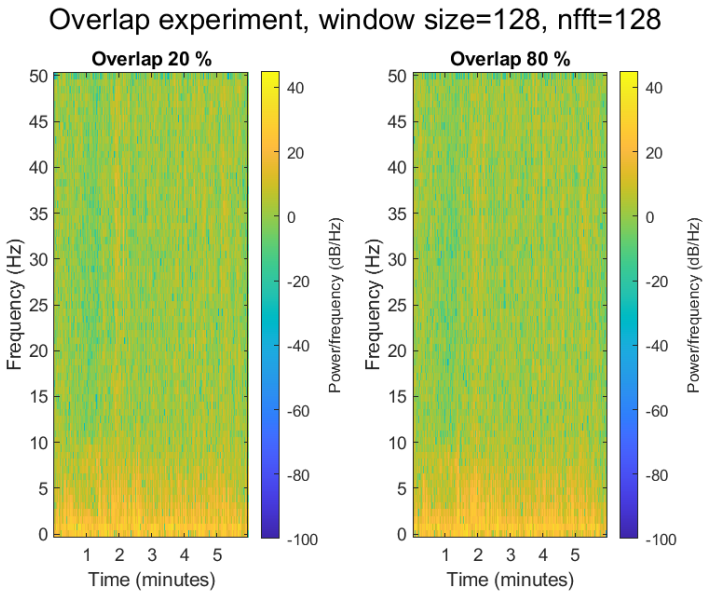

Figure 13 Sleep EEG – overlap

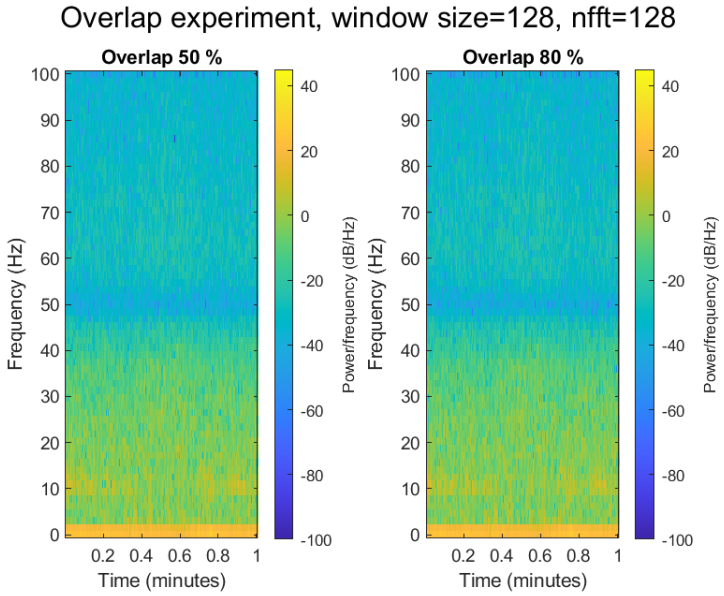

Figure 14 Self-measured EEG – overlap

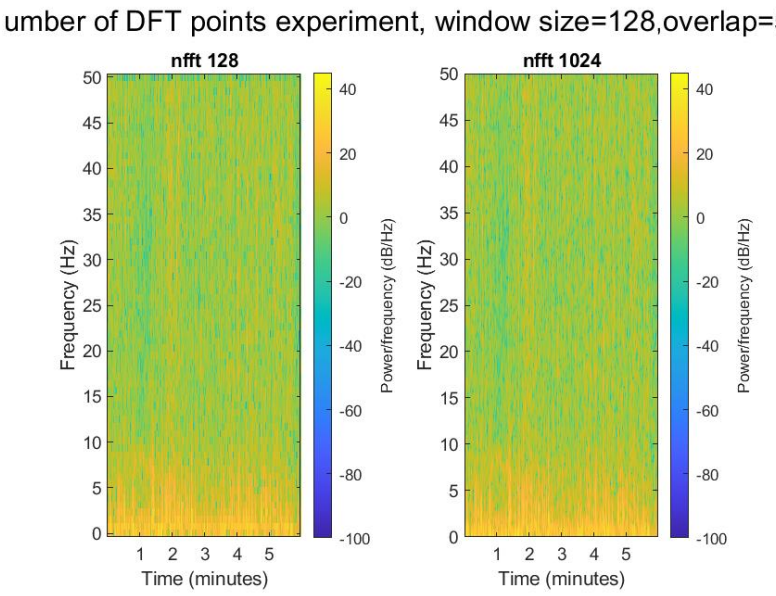

Figure 15 Sleep EEG - DFT points

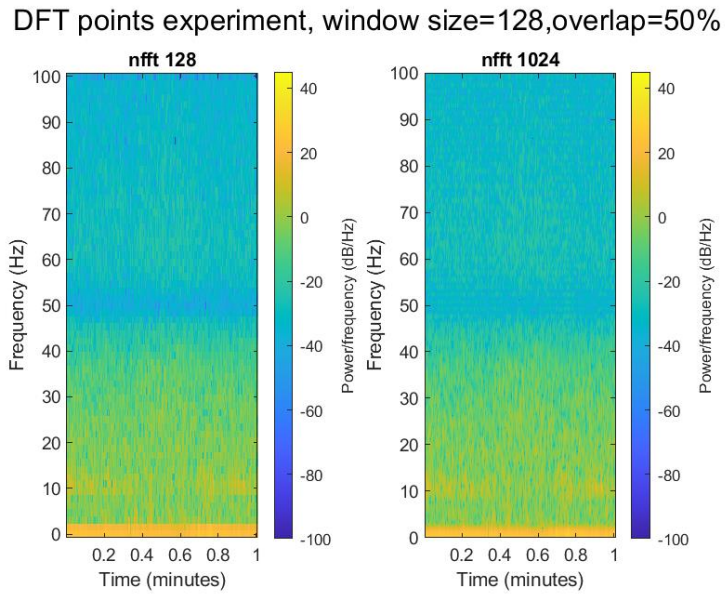

Figure 16 Self-measured EEG - DFT points