



Department of Physiology E-Magazine August/September 2022

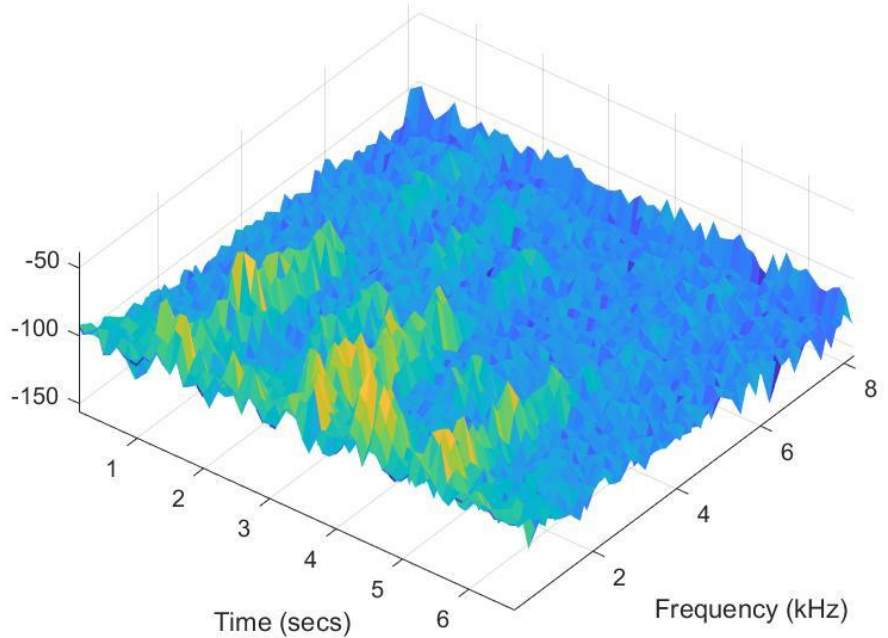
Speech &
Auditory
Tonotopy

The Frequency
Domain in
Biopotentials

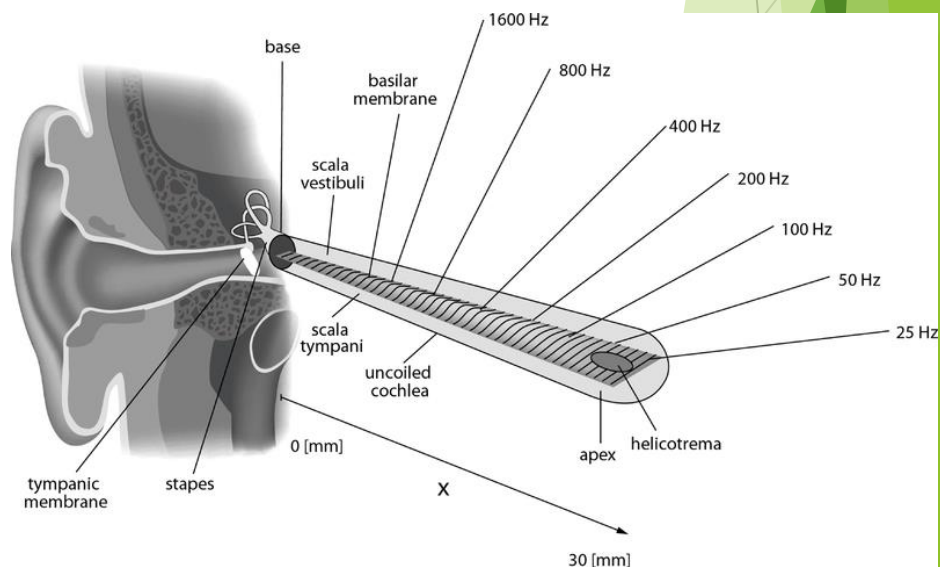
Frequency
Domain
Analysis
- Fundamentals

The Fourier
Transform

I MBBS Student
Comic Strips
and Models



Life in the Frequency Domain





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From the Desk of the Chief Editor

We spend our lives travelling through time – navigating the time domain so to speak. Frequency modulation is a way of encoding information through varying instantaneous frequencies in a waveform. Frequency Modulation can be seen in variety of applications from human speech, music , signaling and tele-communications. Typically, we encounter information as some form as time varying signal – speaking to each other, music

In this issue, we will have a look behind the scenes into the frequency domain of biological processes like hearing and biopotentials like ECG, EEG and EMG. We will also introduce a few tools we can use to study the frequency domain better.

We would also like congratulate the 12 students of the MBBS Class of 2021/22 for their prize winning performances in the model making and comic strip competitions at the All India Physiology Festival conducted by LHMC, New Delhi on September 20-22

-Dr. Chitturi Vinay



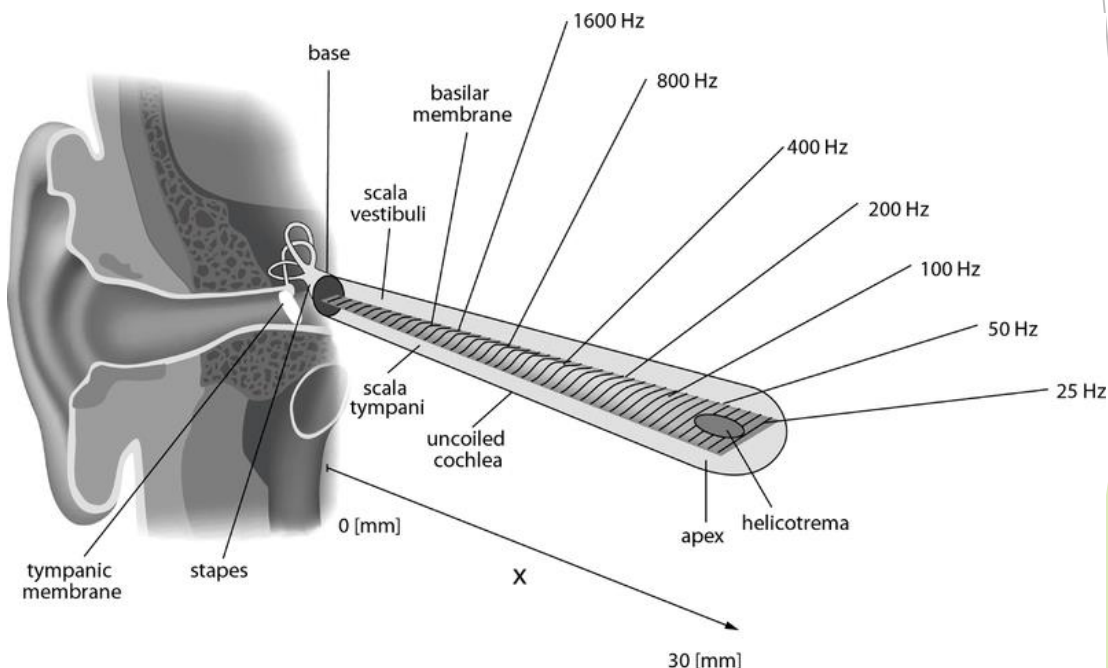
Auditory Tonotopy Basilar Membrane - A spectral analyser

Sound is a pressure wave propagated through a medium. The intensity of this pressure wave is quantified on a logarithmic scale in decibel Sound Pressure level (dB SPL).

$$dB\ SPL = 20 \cdot \log_{10}(P/P_{REF})$$

$P_{REF} = 20\ \mu\text{PA}$ threshold for human hearing

Check out the [Spectrogram lab](#) to see the frequency content of some common sounds and your own voice!



Sound Transduction in the Human Ear

- The energy of the pressure wave is transmitted through the external and middle ear to the perilymph of the Inner Ear.
- These oscillations in the inner ear fluids set up a travelling wave in the basilar membrane
- Depending on the characteristic Frequencies of the sound. The pressure wave sets up a resonant vibration at a specific spot on the basilar membrane stimulating the nearby hair cells



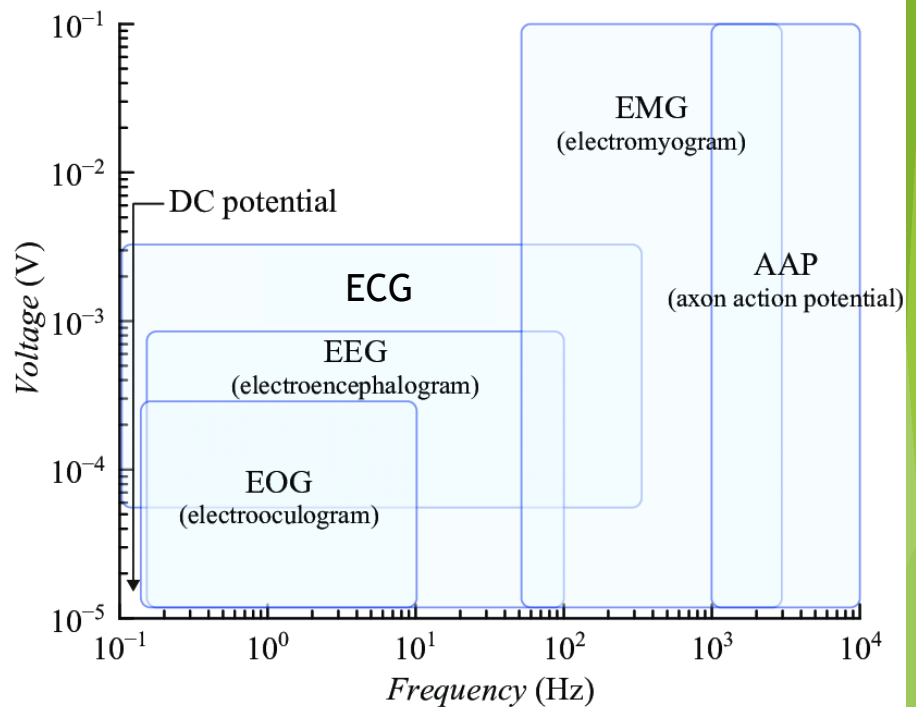
The Frequency Domain in Biopotentials

ECG ; EMG ; EEG ; EOG ; EGG

Biopotentials are time varying electrical signals (voltages) that are generated by physiological processes occurring within the body.

Biopotentials are produced by the electrochemical activity of excitable cells like neurons and muscles

Amplitude and Frequency Ranges of some common Biopotentials



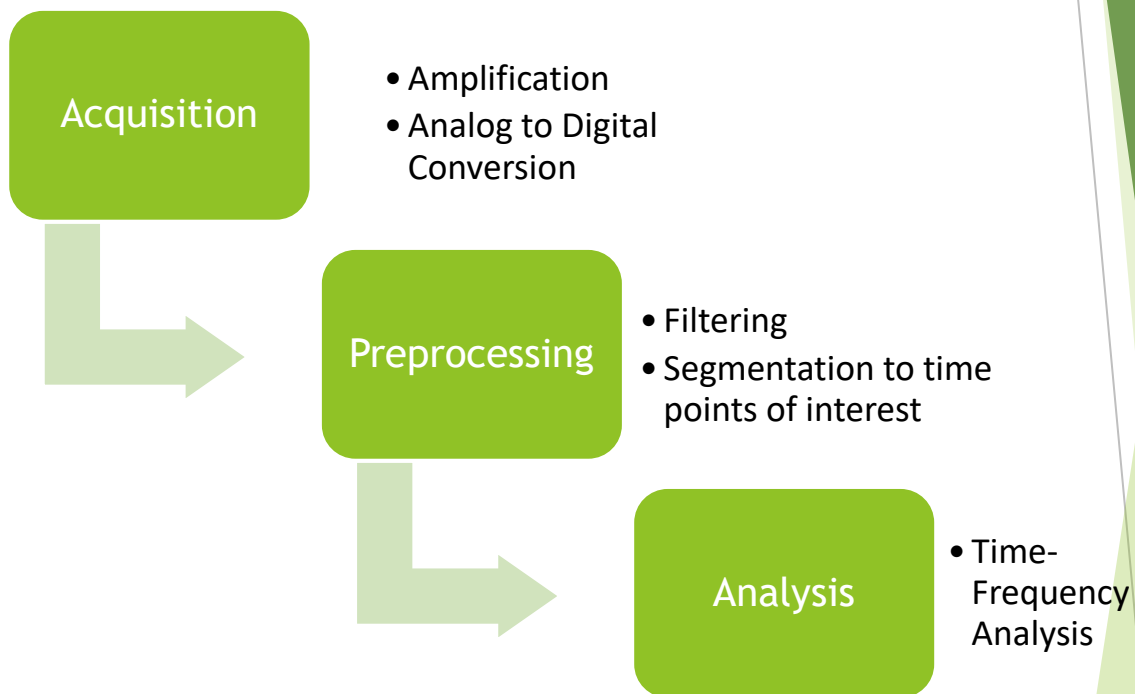
Frequency Modulation in the bioelectric processes of the body underlies physiological processes like

1. Sensory Coding,
2. Motor Unit Recruitment
3. Cortical Entrainment for information exchange



Frequency Domain Analysis - Fundamentals

Workflow in Quantitative Spectral Analysis of Biopotentials

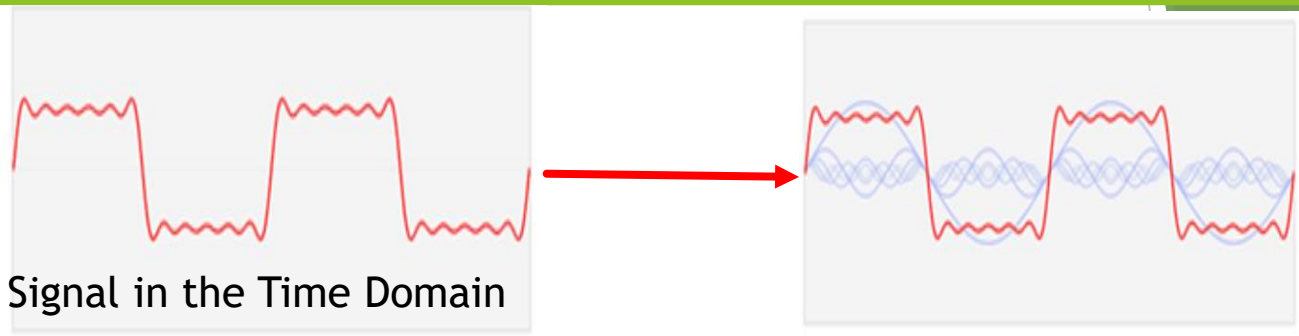


Time- Frequency Analysis Methods

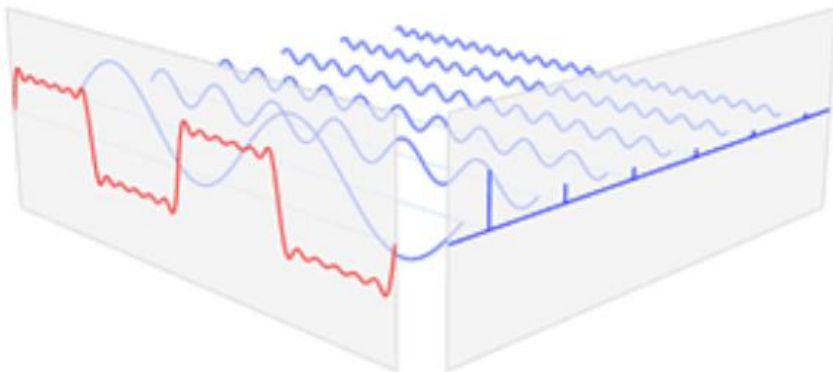
1. Fourier Transforms
2. Wavelet Transform
3. Hilbert Transform
4. Gabor Transform



The Fourier Transform - A Quantitative tool for studying frequency content in Biopotentials



A Signal can be considered as the sum of multiple complex sinusoids of different frequencies



Decomposition of the signal into its component complex sinusoids

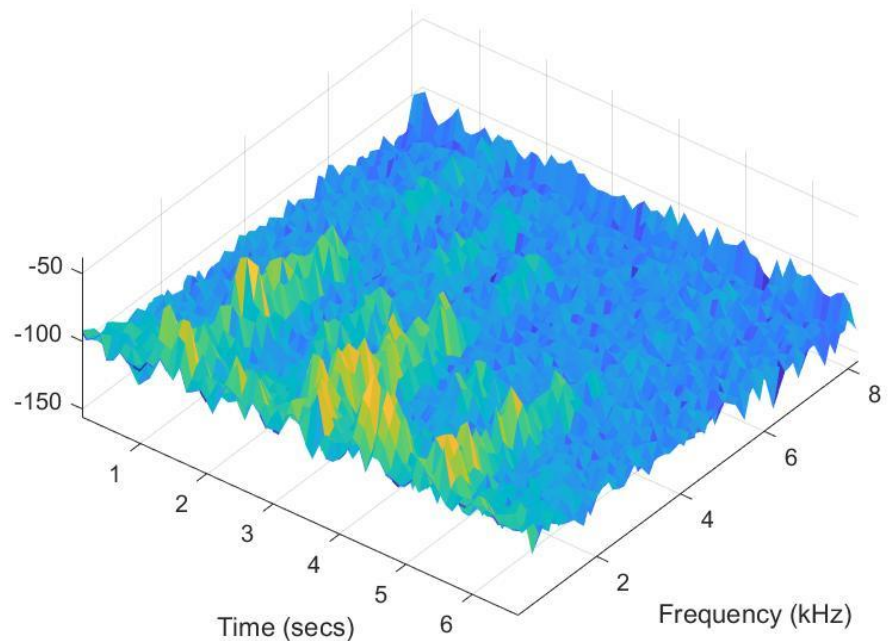


Signal in Frequency Domain depicting contribution of different frequencies



Frequency Domain in Biopotentials - Time Frequency Representations

Time – Frequency Representation of the different frequency components in Human Speech



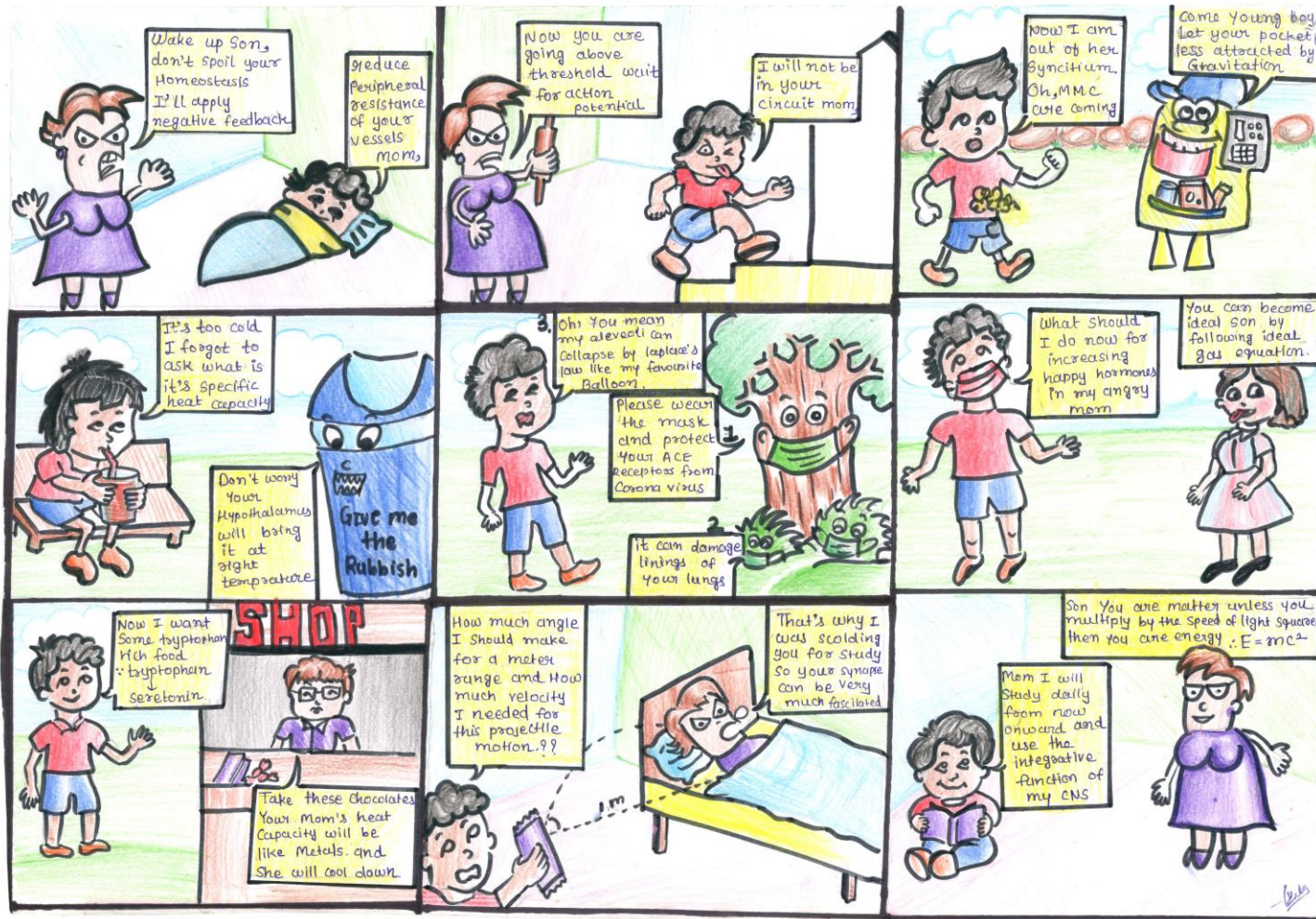
- ▶ Effective Frequency domain analysis requires customization of the user inputs to the algorithm as appropriate for the data being analysed.
- ▶ An Effective solution to this concern is to develop a data analysis pipeline.
- ▶ A Secondary but significant benefit of such data analysis pipelines is the ability to automatise repetitive steps over large datasets.

List of open source Programming Languages used commonly in Numerical Computing

1. **Python**
2. **Octave** – open source implementation of MATLAB
3. **R**
4. **Julia**



Comic Strip - Physics in Physiology - Ms. Urvi Zala (MBBS Class of 2021/22)



Physics in Physiology - Models

00:00 A) Model 1 - Renal Hemodynamics Team Hydraulics (MBBS 2021) - Ashmit, Nirvighnam, Istikhar, Raj, Aayush

03:01 B) Model 2 - Working model of Extraocular movements - Agonist and Antagonist muscles Team Brainiacs (MBBS 2021) - Soumya, Khushal, Pearl, Milan , Priyanshu, Krutagna

