Empirical Mode Decomposition To Find Instantaneous Frequency Project Report

Ayush Singhania(20171031)

Kunal Lahoti(2018122002)

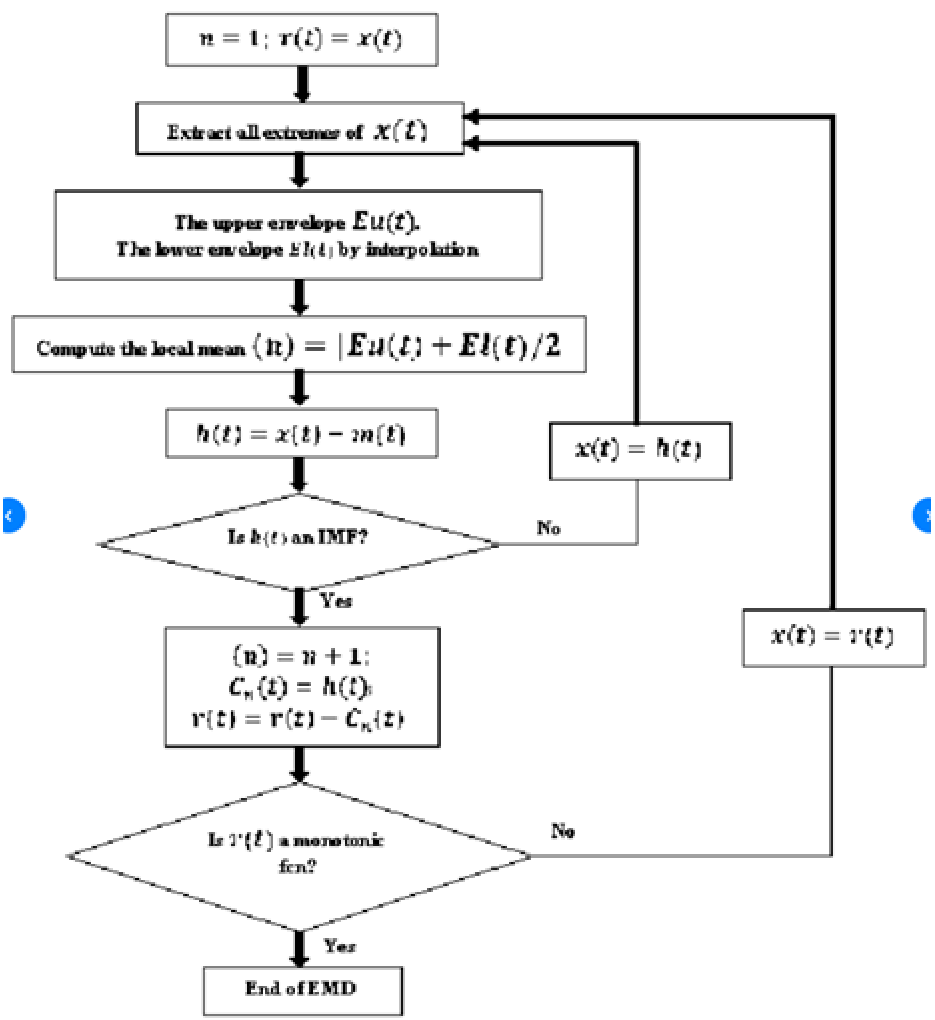
Aim of the Project: To decompose a non-linear, non-stationery signal into component IMFs using Empirical Mode Decomposition to find the component Instantaneous Frequencies present in the signal.

Basic Algorithm For Finding IMFs(EMD):

1. Identify all the local extrema in the test data.
2. Connect all the local maxima by a cubic spline line as the upper envelope.
3. Repeat the procedure for the local minima to produce the lower envelope.
4. The upper and lower envelopes should cover all the data between them. Their mean is m_1. The difference between the data and m_1 is the first component h_1: $X(t) - m_1 = h_1$.
5. Ideally, h_1 should satisfy the definition of an IMF, since the construction of h_1 described above should have made it symmetric and having all maxima positive and all minima negative. After the first round of sifting, a crest may become a local maximum. New extrema generated in this way actually reveal the proper modes lost in the initial examination. In the

subsequent sifting process, h_1 can only be treated as a proto-IMF. In the next step, h_1 is treated as data: $h_1 - m_{11} = h_{11}$.

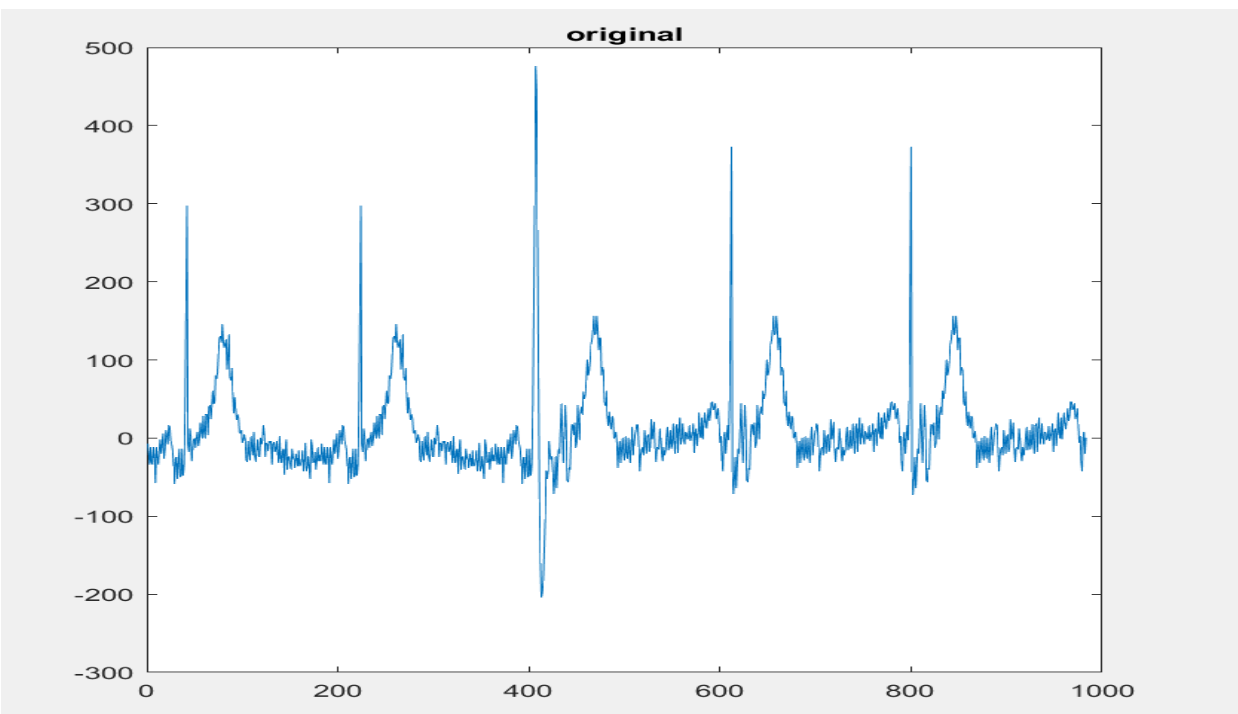
6. After repeated sifting up to k times, h1 becomes an IMF, that is $h_{1(k-1)} - m_{1k} = h_{1k}$.
7. Then, h_{1k} is designated as the first IMF component of the data: $C_1 = h_{1k}$.
8. The stoppage criterion determines the number of sifting steps to produce an IMF.
9. The stoppage criteria we chose is: Standard Deviation < 0.3.



Basic Algorithm for Finding Instantenous Frequncy from IMFs:

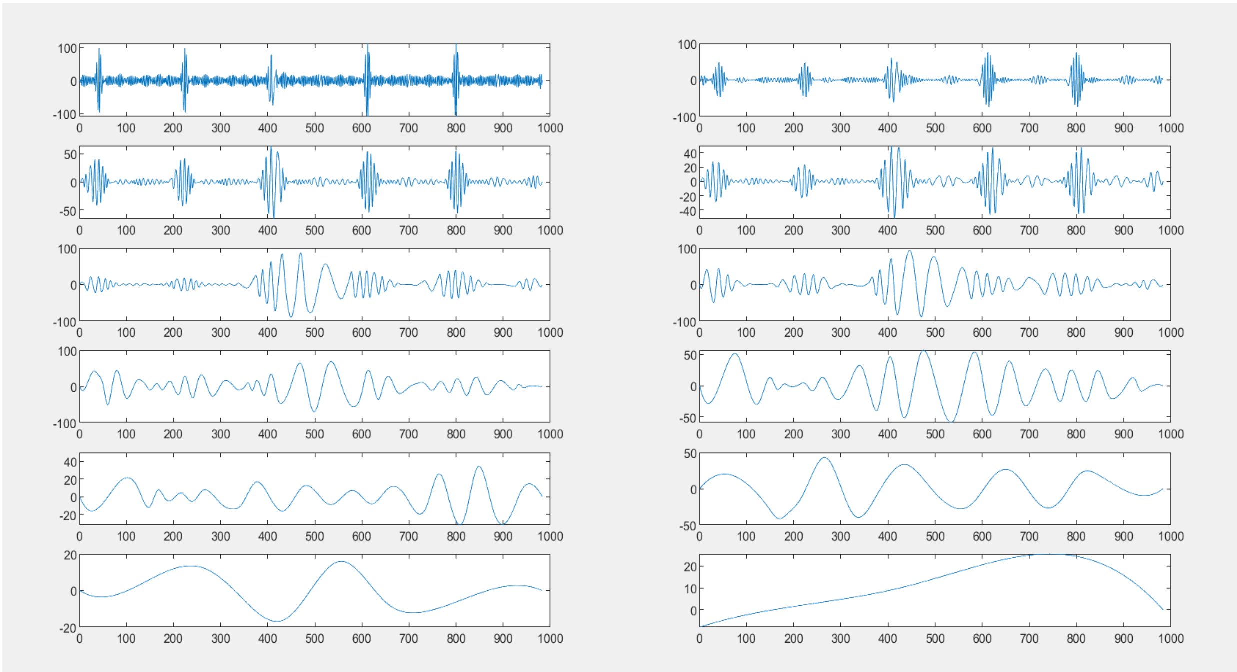
1. Find the IMF components which contain 99% of the signal power and compute Instantaneous Frequencies from them.
2. Compute analytical signal, $z(t) = s(t) + j*H[s(t)] = a(t)*e^{j*\phi(t)}$, where s(t) is the real signal (an IMF), H[*] is Hilbert transform, a(t) is the absolute value of z(t), and $\Phi(t)$ is the phase of z(t).
3. Instantaneous frequency, $f_i(t) = (1/(2*\pi))*(d\phi(t)/dt)$

Input Signal : We chose a standard ECG signal for testing our code. The ecg signal is plotted as:

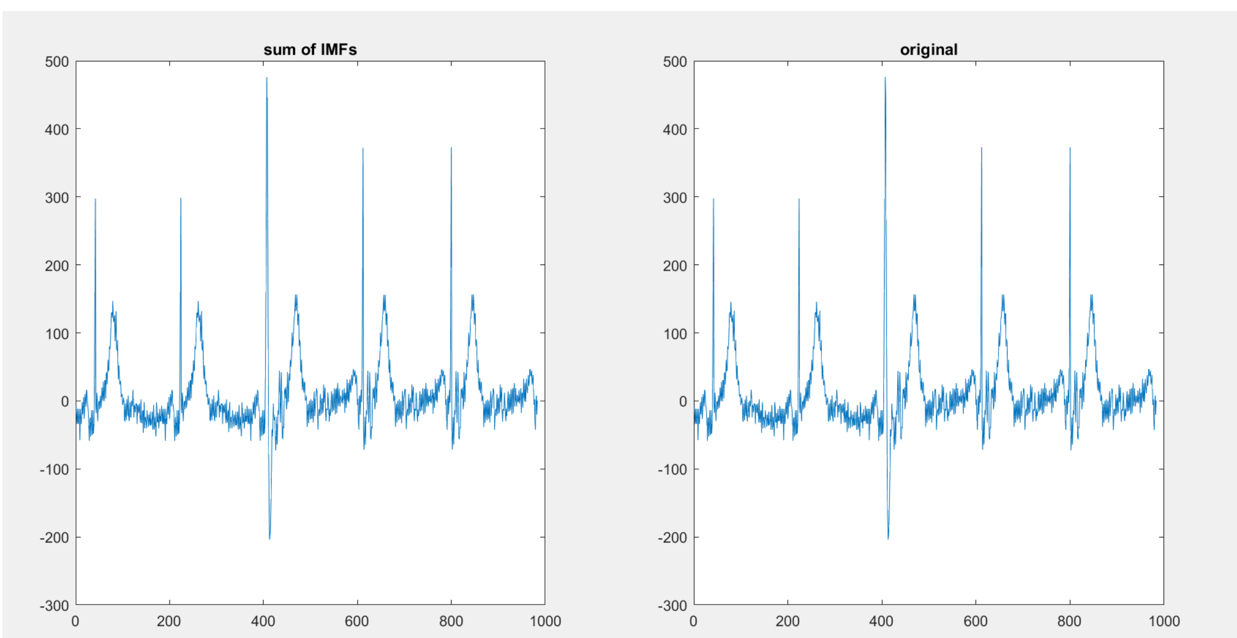


Outputs:

1. Component IMFs:

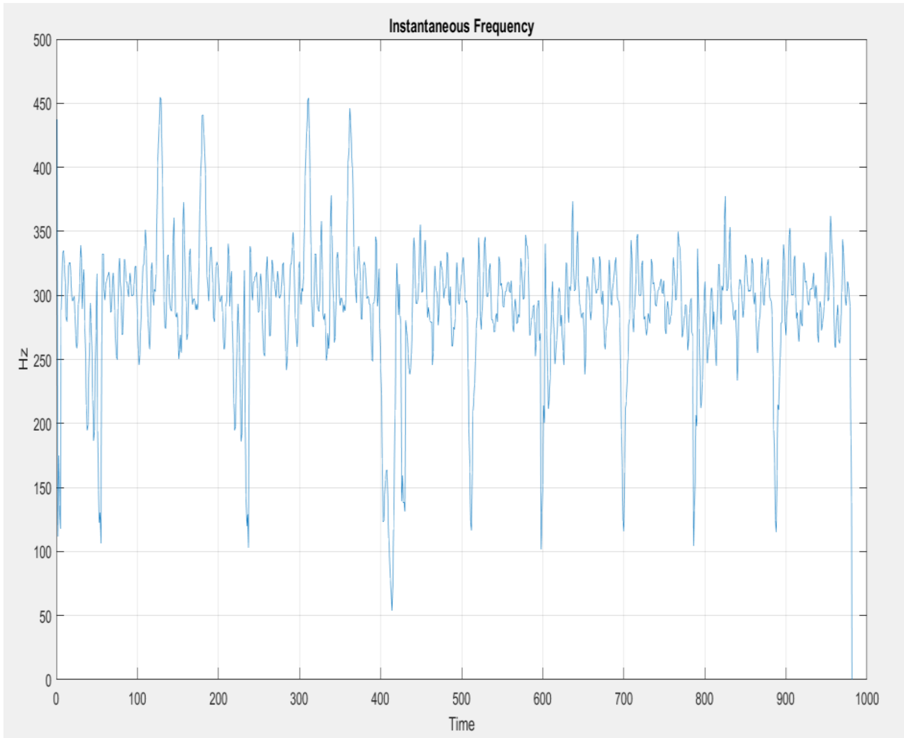


2. Sum of IMFs:

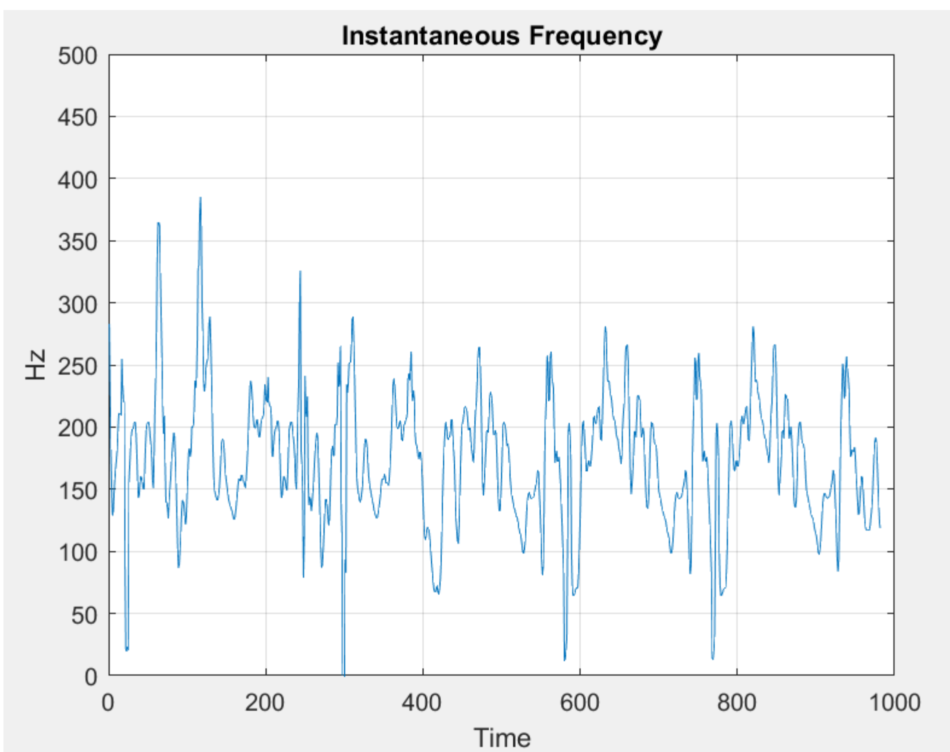


3. Component Instanteneous Frequencies:

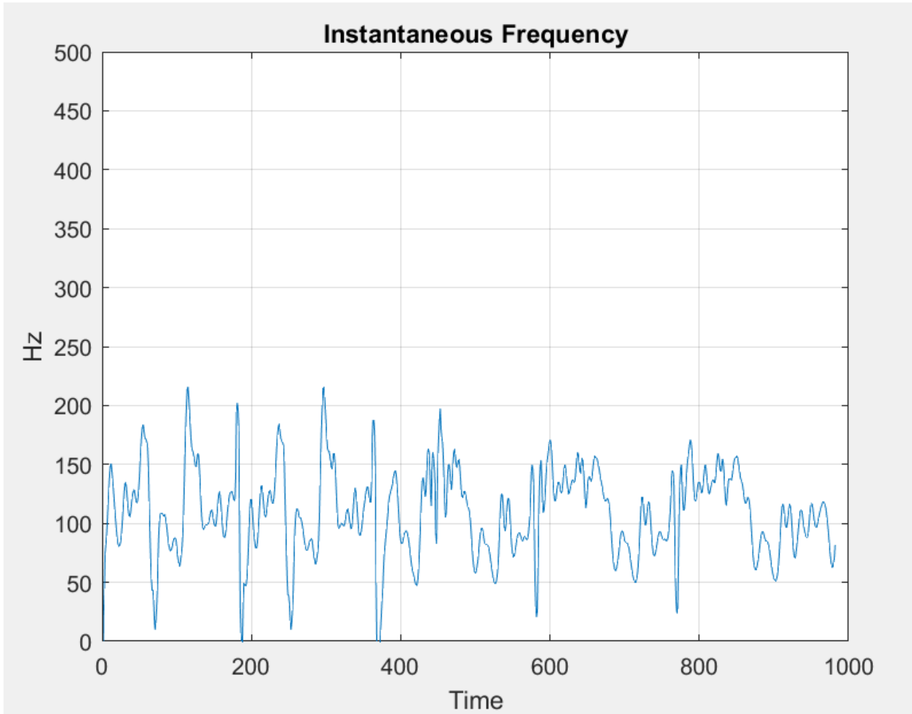
a. Frequency = 300 Hz.



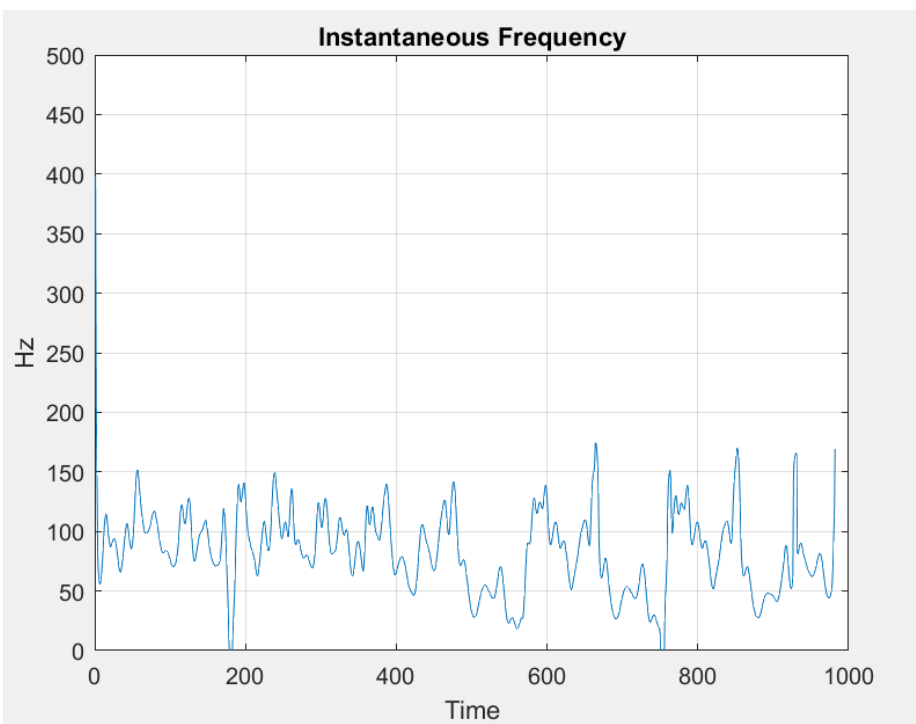
b. Frequency = 160 Hz



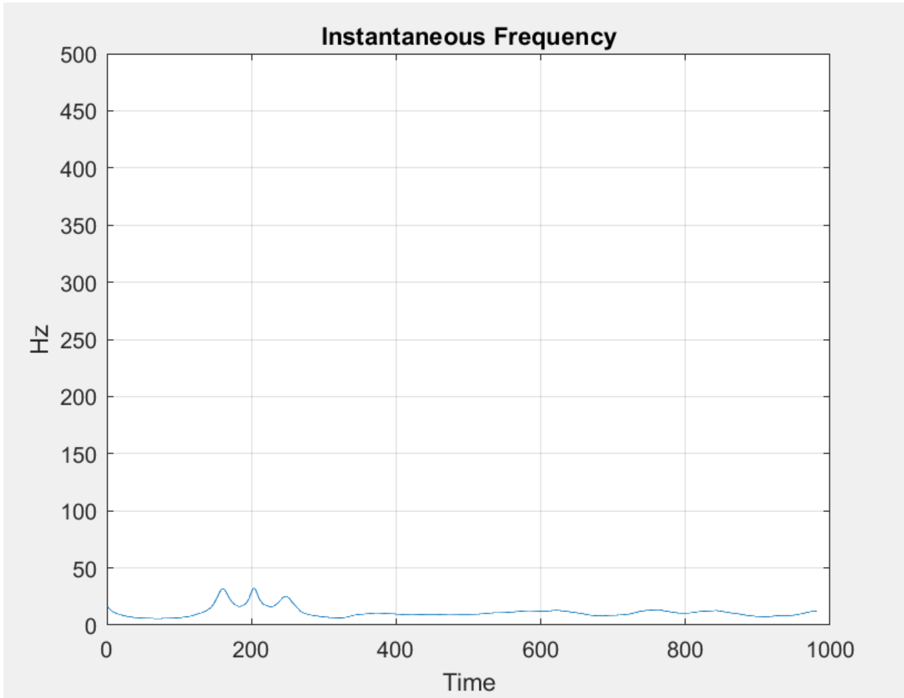
c. Frequency = 100 Hz



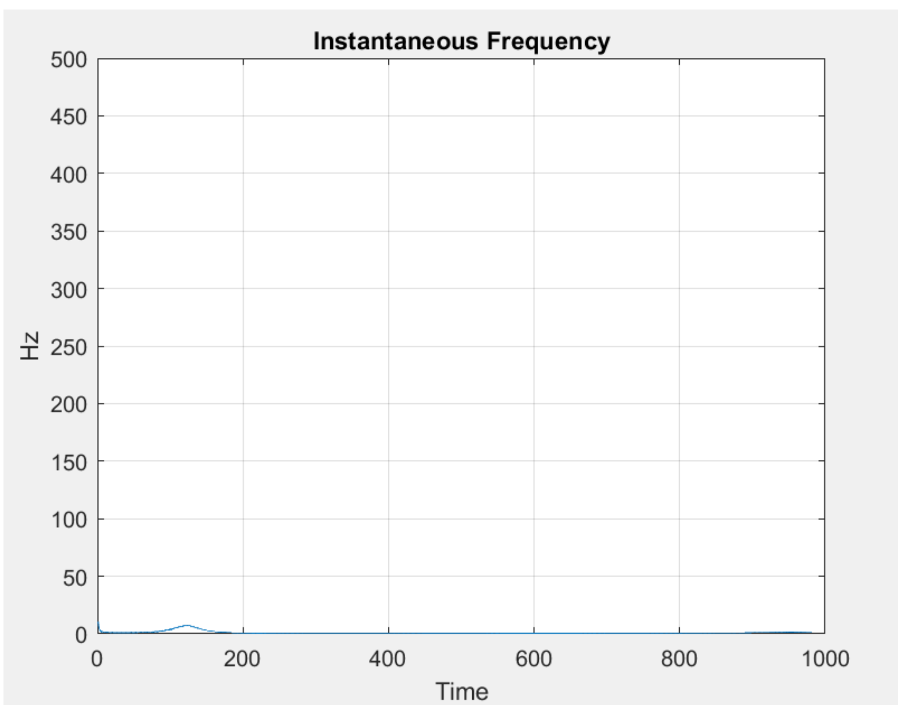
d. Frequency = 80 Hz



e. Frequency = 20 Hz



f. Frequency = 5 Hz



<u>Observations:</u> The input ECG signal contains 300 Hz as the most dominant R-peak frequency as is expected in a normal ECG scan. The other frequencies correspond to the other peaks like Q,S,T etc.
