Frft based 2rd order Poly -Bohman window for ECG de-noising

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Abstract

FIR (finite impulse response) filters with window based design is quite common in signal processing for removing noise in signals. There are many windows available for signal processing such as hamming, hanning, blackmann, etc.Here an attempt is made to improve spectral characteristic like RSA of bohmann window by using fractional Fourier transform which is applied to combination of Bohman window and 2rd order polynomial window. The new window function is then applied for removal of power line noise from ECG [2].

Keywords: RSA, FRFT

1. INTRODUCTION

ECG (Electro Cardio Gram) is medical signal which usually carries information regarding heart. The recording process of ECG is prone to noise. The important noise of kind is power line noise which will disturb the signal pattern of ECG. Here a new window based FIR filter is used for removal of power line noise. The ECG signal pattern is shown below

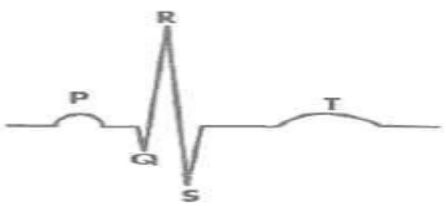

Figure-1: ECG wave

The electrical cavity results in p, QRS, and T waves that are of different sizes and shapes. When viewed from different leads, these waves can show a wide range of abnormalities of both the electrical conduction system and the muscle tissue of the hearts 4 pumping chambers.

2. FRACTIONAL FOURIER TRANSFORM:

The fractional Fourier transform was first introduced by Namias [3] in its incomplete form. The FrFT can be expressed as:

$$X_\alpha(t_\alpha) = \int_{-\infty}^{\infty} x(t)\, K_\alpha(t_\alpha, t)\, dt \qquad \ldots\ldots (1)$$

Where:

$$K_\alpha(t_\alpha, t) = K_\phi \exp\left[j\pi\left(t_\alpha^2 \cot\phi - 2t_\alpha t \operatorname{cosec}\phi + t^2 \cot\phi\right)\right]$$

$$K_\phi = |\sin\phi|^{-1/2} \exp\left[\frac{-j\pi\ \mathrm{sgn}(\sin\phi)}{4} + j\frac{\phi}{2}\right]$$

$$\text{and} \quad \phi = \frac{\alpha\pi}{2}.$$

3. CONCEPT OF POLYNOMIAL WINDOWS [1]:

$$w_m(t) = 1 - K_m \sum_{n=0}^{m} A_{m,n} |t|^{2m-n+1}, \quad -1 \le t \le 1. \qquad \ldots\ldots 2$$

Where:

$$K_m = \frac{(2m+1)!(-1)^m}{(m!)^2} \qquad A_{m,n} = \frac{(-1)^n\ {}^mC_n}{2m-n+1}.$$

4. THE PROPOSED WINDOW FUNCTION:

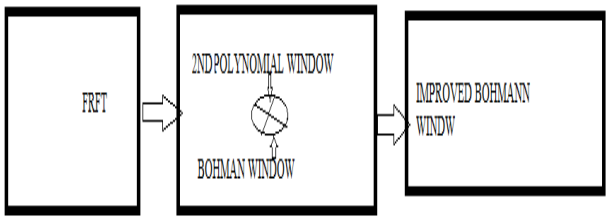

Figure-2

Frft is applied to the convolution of Bohman window and 3rd order polynomial window to improve the RSA of combined window function.

5. THE RESPONSE OF 2RD ORDER POLYNOMIAL WINDOW:

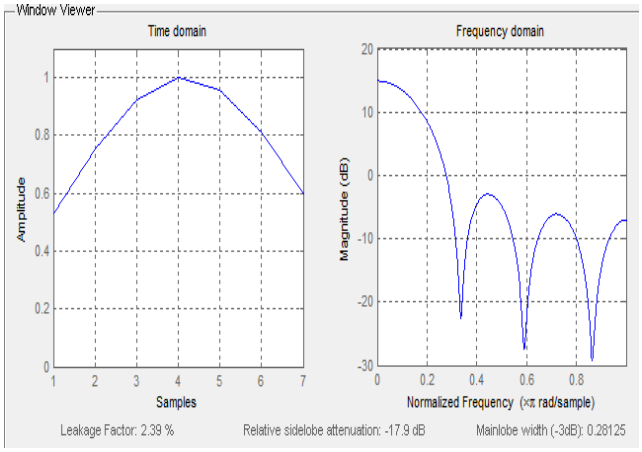

Figure-3 the RSA of polynomial window with order 2

6. THE RESPONSE OF BOHMAN WINDOW:

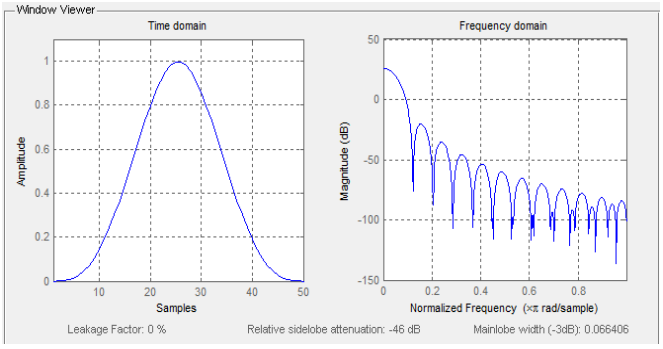

Figure-4 the RSA of bohman window

7. THE RESPONSE OF PROPOSE D WINDOW FUNCTION:

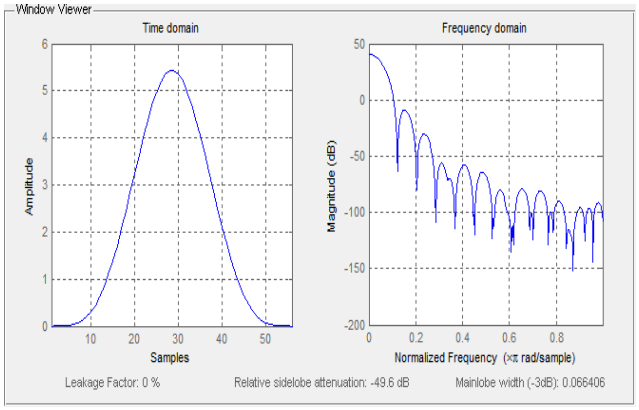

Figure-5 the RSA of improved Bohman window function

TABLE-1:

window	RSA(dB)	Main lobe width
2nd order polynomial	-17.9	0.2815
Bohman window	-46	0.066406
Improved Bohman window	-49.6	0.066406

From Table-1 it is observed that the Relative side lobe attenuation of bohman window is improved by applying fractional Fourier transform with the concept of polynomial window of second order.

8. THE FILTER FOR NOISE REMOVAL:

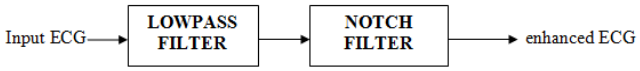

Figure-6 The filter for noise removal

Our ECG signal is applied to a low pass filter for which the output will be an ECG with the removal of frequencies above 120 Hz interference. Then the resulting signal is applied to the NOTCH filter where the power line interference is removed. The enhanced ECG signal with the removal of power line interference is collected at the output.

9. RESULTS:

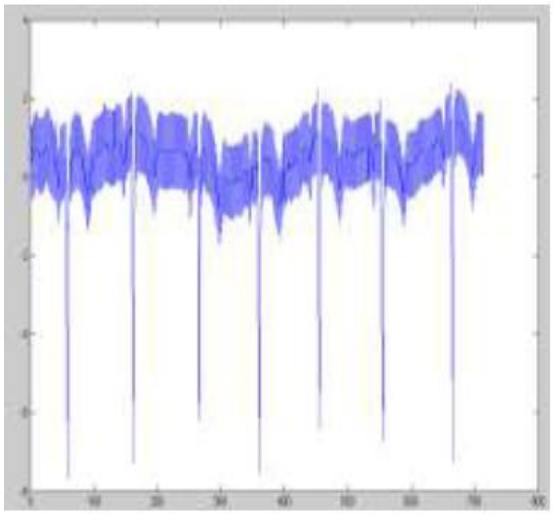

Figure-7 noisy ECG signal

Filtered ECG signal:

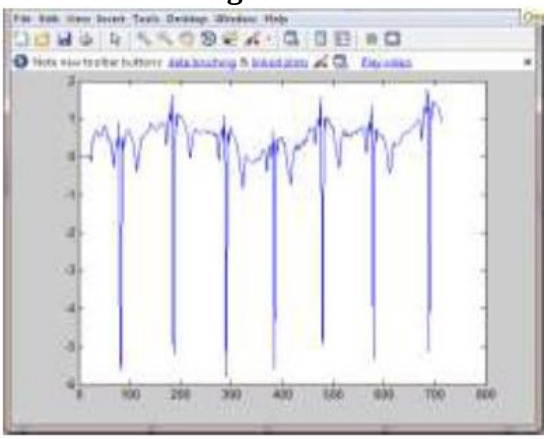

Figure- 8 output from the filter

CONCLUSION

From figure 8 is very clear that the proposed window based filter eliminates power line interference very effectively. In our paper attempt is made only eliminate power line interference similarly many more artifacts of ECG can be removed with our proposed improved FIR filter which can be encouraged.

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