

Signal Analysis of Real Time Signals to Remove Noise

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Abstract- Removal of noise is very important branch in Digital Signal Processing. This paper addresses the analysis of real time signals to finally remove noise from the signals. In the proposed technique these signals are analyzed by comparing the results in Spectrum Analyzer and MATLAB. This is performed by evaluating the FFTs first and Hanning window is applied to it. Similar process is done in MATLAB. Also noise is introduced to the signals and in the same time removed. By analyzing these real time signals we can say that the results in Spectrum Analyzer are almost same with the results in MATLAB.

Keywords: Real Time Signal , Analysis, MATLAB, Spectrum Analyzer, FFT, Frequency, Filter, Noise.

I. INTRODUCTION

A signal is a physical quantity that varies with time space or any other independent variable by which information can be conveyed. A real discrete-time signal is defined as any time-ordered sequence of real numbers.

The Fast Fourier Transform is an algorithm optimization of the DFT—Discrete Fourier Transform. It is an algorithm to compute the Discrete Fourier Transform (DFT) and its inverse. A Fourier Transform converts time (or space) to frequency and vice versa. A FFT rapidly computes such transformations. As a result, Fast Fourier Transforms are widely used for many applications in engineering, science, and mathematics. It takes a part of time called a frame (a certain number of samples) and considers that part to be a single period of a repeating waveform. The fourier transform aims to decompose a cycle of an arbitrary waveform into its sine components. Windowing is a technique used to shape the time portion of a measured data, to minimize edge effect that result in spectral leakage in the FFT spectrum. It premultiplies input data supplied to the FFT with a value that smoothly decreases to zero at each end of data. The purpose to reduce “leakage” in the FFT outputs that are introduced by sudden changes in the data at the start and end of data. Here is a demonstration of how windowing can improve the Fourier Transform result which is shown in fig. 1. Agilent Intuilink removes the barrier between instruments and PCs, allowing measurement data to be accessed instantly, easily, whenever and wherever it’s needed—in design verification, manufacturing test, process control, and data acquisition. Here, it is used to interface with PC to capture the images in Spectrum Analyzer. It also provides with the respective data sheets with which further coding is done in MATLAB.

Manuscript published on 30 October 2013.

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A low pass filter is a filter that passes low frequency

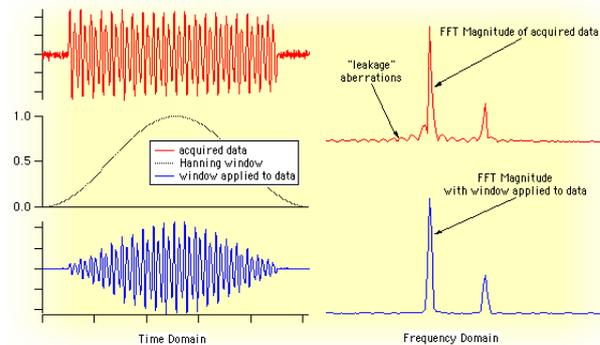


Fig. 1 Improved Fourier Transform after windowing

signals and reduces the amplitude of signals which have higher frequencies than cutoff frequency. It has various forms which include electronic circuits, anti-aliasing filters for conditioning signals, digital filters for smoothing sets of data and so on. Low pass filter provides a smoother form of a signal by removing short-term fluctuations. It is a circuit which can be designed to reshape, modify or reject all unwanted frequencies of an electrical signal.

Chebyshev filters are analog digital filters in which the transmission frequency curve has an equal-ripple shape, with very small peaks and valleys. They have a steeper roll-off and more passband ripple(type I) or stopband ripple(type II) than Butterworth filters. They are used to separate one band of frequency from another. The squared magnitude response of a Chebyshev low-pass filter is defined as follows

$$|H(j \cdot \omega)|^2 = \frac{1}{1 + \epsilon^2 \cdot T_N^2\left(\frac{\omega}{\omega_{scale}}\right)}$$

where

- $\omega = 2 \cdot \pi \cdot f$ - Angular frequency
- $\omega_{scale} = 2 \cdot \pi \cdot f_{scale}$ - Constant scaling frequency
- N - Order of the filter
- ϵ - Parameter that characterizes ripple
- $T_N(x)$ - Chebyshev function of degree N

Butterworth filter is a type of signal processing filter that is designed to have as flat a frequency response as possible in the passband. The squared magnitude function for an nth order Butterworth low-pass filter is defined as follows



$$|H(j \cdot \omega)|^2 = \frac{1}{1 + \left(\frac{\omega}{\omega_{scale}}\right)^{2N}}$$

where $\omega = 2 \cdot \pi \cdot f$

radian frequency, $\omega_{scale} = 2 \cdot \pi \cdot f_{scale}$ - constant scaling frequency, N - order of the filter.

Noise is unwanted electrical or electromagnetic energy that degrades the quality of signals and data. Noise occurs in digital and analog systems, and can affect files and communications of all types, including text, programs, images, audio and so on. The types of noise are thermal noise, shot noise, flicker noise, burst noise, transit time noise and avalanche noise. Additive white Gaussian noise(AWGN) which is a part of thermal noise, is considered here.

II. METHODOLOGY

In this paper, three real time signals are considered, i.e. Sine, Square and Triangular waves. Apparatus needed are

- 1) A Spectrum Analyzer,
- 2) A Signal Generator and
- 3) Agilent Intuilink Software

These signals are observed in the Spectrum Analyzer with 10KHz frequency each. FFT of the signals are calculated in the analyzer. The frequency spectrum is windowed for a certain range using Hanning Window.

The Spectrum Analyzer is then interfaced with PC by Agilent Intuilink. With the help of this software, images of the signals with their FFT are captured. Data sheets of each of the signal are obtained. The data sheets are read in MATLAB using the appropriate command. First FFT is evaluated and then the frequency spectrum is windowed. The steps followed here are same as that in Spectrum Analyzer. The results are compared with the result in Spectrum Analyzer. Both the outputs are not exactly same and they almost resemble with each other.

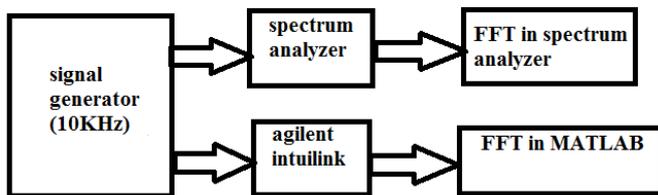


Fig. 2 Block Diagram of analysis of the signals using Spectrum Analyzer and MATLAB

AWGN noise is introduced to these signals. In the same way, FFT and then windowing are done in MATLAB. The noisy output is completely different from the previous output. In the next step, noise from the signals are removed by using filters. The filters used are:

1. Butterworth Filter
2. Chebyshev Filter

Thus original signals are obtained by filtering. Also filter is applied to noisy windowed output. As a result, the output obtained is a smooth curve where all the noises are removed.

III. RESULTS

Butterworth filter and Chebyshev filter are used to remove noise from these signals such as ‘Sine Wave’ is considered. The following figures show the outputs of the signals. As can be observed from the results:

1. Fig. 3 is the Original Sine Wave in MATLAB
2. Fig. 4 is the Sine Wave With Noise in MATLAB
3. Fig. 5 is the FFT of Sine Wave After Windowing in MATLAB
4. Fig. 6 is the FFT of Noisy Sine Wave After Windowing in MATLAB
5. Fig. 7 is the Filtered FFT of Noisy Sine Wave After Windowing Using Butterworth Filter
6. Fig. 8 is the Filtered FFT of Noisy Sine Wave After Windowing Using Chebyshev Filter
7. Fig. 9 is the Captured Sine wave in Spectrum Analyzer with its FFT

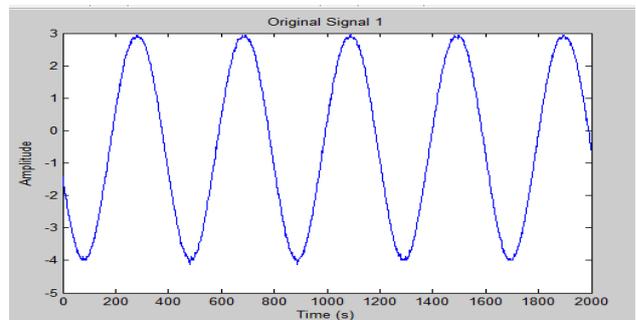


Fig. 3 Original Sine Wave in MATLAB

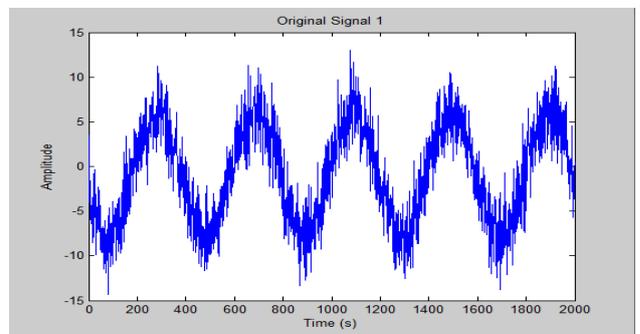


Fig. 4 Sine Wave With Noise in MATLAB

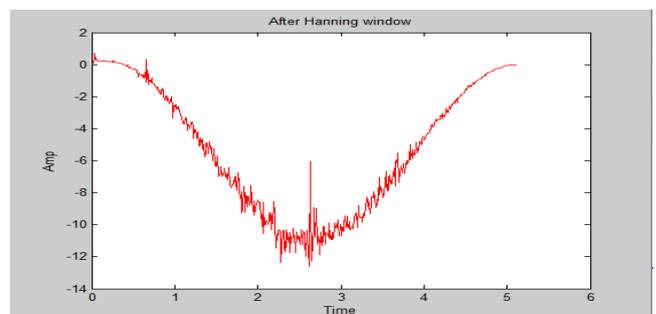


Fig. 5 FFT of Sine Wave After Windowing in MATLAB



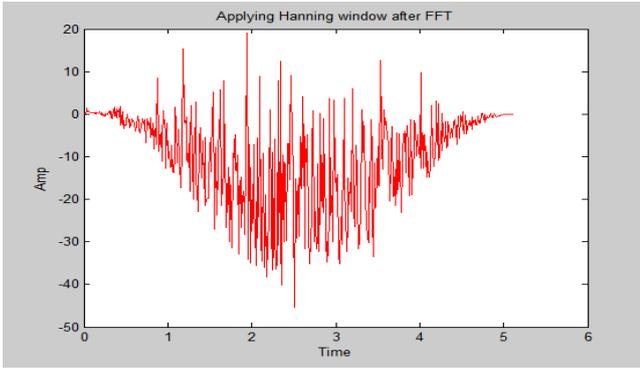


Fig. 6 FFT of Noisy Sine Wave After Windowing in MATLAB

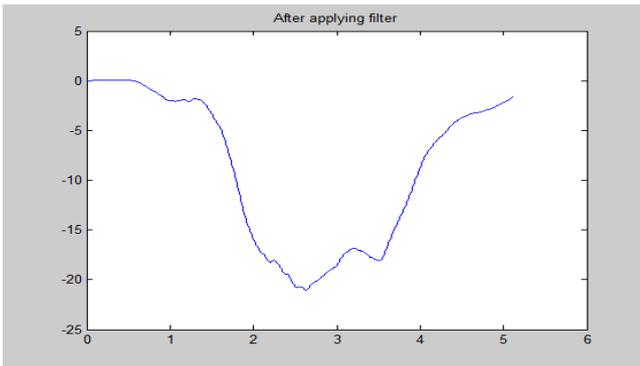


Fig. 7 Filtered FFT of Noisy Sine Wave After Windowing Using Butterworth Filter

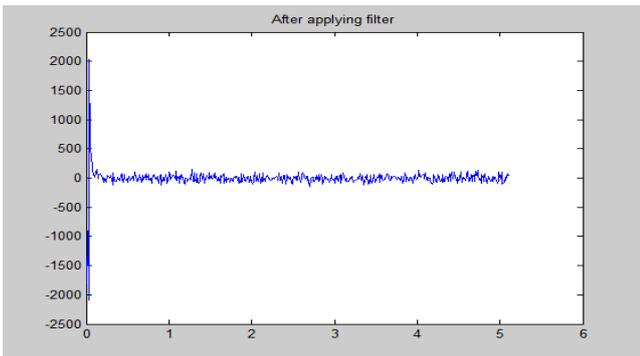


Fig. 8 Filtered FFT of Noisy Sine Wave After Windowing Using Chebyshev Filter

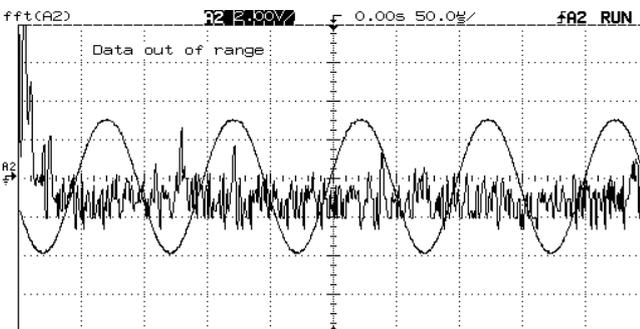


Fig. 9 Captured Sine wave in Spectrum Analyzer with its FFT

V. CONCLUSION

For signal analysis of real time signals, Spectrum analyzer, Agilent Intuient software and MATLAB are used for obtaining desired results. The FFT was performed on all the three signals and the frequency spectrum was windowed. Noise was introduced to these signals and later removed by

using Butterworth and Chebyshev filters. The results obtained in Spectrum analyzer and MATLAB have got resemblance.

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