ISSN 2348 – 9928
IJAICT Volume 2, Issue 7, July 2015 Doi:01.0401/ijaict.2014.03.07 Published Online 05 (07) 2015

PERFORMANCE ANALYSIS LEAKAGE ELIMINATION METHOD FOR ESTIMATION OF PARAMETERS OF EXPONENTIAL SIGNAL USING WINDOWING TECHNIQUE

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Abstract— ***In physical systems, dynamic behaviour can be expressed in differential equations. The results of any linear and time- invariant or differential equations are mostly composed of exponential forms. Exponential signals in the frequency domain or accurately analysed by an algorithm & the peaks of the discrete Fourier transform (DFT) results are adopted to obtain parameters that include amplitude, frequencies, damping and phases. Thus, these two types of exponential forms, if the damping is equal to zero, the mode is periodic & if the damping is not equal to zero the mode is aperiodic & thus it will decay to zero with time. If signal is periodic, the analysis method for periodic signal can be divided into time & frequency domain methods. If signal is aperiodic, it can also be divided into time & frequency domain method. Frequency domain can display the important messages that are hidden behind the signal; therefore the uses of such method can deal with computer system & quickly deduce solutions. The leakage is the most critical factor during signal parameters estimation. The leakage arises due to the side band frequency. Leakage is defined as the interference between side band frequencies. The amplitude, frequency, damping, and phase of exponential signals are analysed accurately in frequency domain by DFT algorithm, and the peaks of the discrete Fourier transform (DFT) result are adopted to obtain parameters that include amplitudes, frequencies, damping, and phase. The transform technique is used for analysis of signal parameters, Fourier technique is used for analysis of signal in frequency domain which gives frequency and phase related information of the signal.***

Keywords — DFT, IpDFT, FFT, DFT.

I. INTRODUCTION

In physical systems, dynamic behaviour can be expressed in differential equations. The results of any linear and time-invariant or differential equations are mostly composed of exponential forms. Exponential signals in the frequency domain or accurately analysed by an algorithm & the peaks of the discrete Fourier transform (DFT) results are adopted to obtain parameters that include amplitude, frequencies, damping and phases. Thus, these two types of exponential forms, if the damping is equal to zero, the mode is periodic & if the damping is not equal to zero the mode is aperiodic & thus it will decay to zero with time. If signal is periodic, the analysis method for periodic signal can be divided into time & frequency domain methods. If signal is aperiodic, it can also be divided into time & frequency domain method. Frequency domain can display the important messages that are hidden behind the signal; therefore the uses of such method can deal with computer system & quickly deduce solutions.

This establishes an algorithm to analyse the parameter of exponential signals in the frequency domain. In frequency domain, the mode energy will centralize near its frequency; therefore the frequency of a node will be located near its spectral peak. This considers that a spectral peak on a spectrum is then number of modes. This peak hides four unknown parameters, frequency, damping, amplitude & phase. The leakage is the most critical factor during signal parameters estimation. The leakage arises due to the side band frequency.

Leakage is defined as the interference between side band frequencies. The amplitude, frequency, damping, and phase of exponential signals are analysed accurately in frequency domain by DFT algorithm, and the peaks of the discrete Fourier transform (DFT) result are adopted to obtain parameters that include amplitudes, frequencies, damping, and phase. The transform technique is used for analysis of signal parameters, Fourier technique is used for analysis of signal in frequency domain which gives frequency and phase related information of the signal. The results of linear and time-invariant differential equations are mostly composed of exponential forms. If the damping is equal to zero, the mode is periodic; conversely, if the damping is not equal to zero, the mode will be aperiodic, and it will decay to zero with time.

In this paper simple and effective formulas are given to analyse these parameters by reconstructing the spectrum of a signal, so that the parameters may be found accurately.

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Consequently, there are four parts of the section:-

1. Calculate the parameters using DFT algorithm.
2. Calculate parameters using interpolated DFT algorithm.
3. The spectrum of an exponential signal.
4. Leakage elimination and influence of noise

In general, any signal consists of several independent modes. Every mode can be taken as exponential forms creating its own spectral peak on the spectrum.

II. GENERATION OF EXPONENTIAL SIGNAL

1. In general, any signal consists of several independent modes. Every mode can be taken as an Exponential form creating its own spectral peak on the spectrum.
2. Referring to this spectral peak, we can calculate all modes. Each mode sustain aliasing from others mode, generating errors.
3. To find more accurate parameters this aliasing must be eliminated.

The exponential form are taken as modes in this, consisting of 'L' independent modes, the signal can be expressed as

$$x(n) = \sum_{l=1}^{L} A_l e^{-\alpha_l n/N} \cos(2\pi f_l / N + \phi_l) \quad \ldots\ldots\ldots\ldots \quad (1)$$

n= 0, 1, N-1

For this paper generate one exponential signal having limits on X-axis 0.1 to 10 and on Y-axis 0 to 1.Also consider a one cosine signal with same phase and multiply this signal with exponential and I get resultant exponential signal.

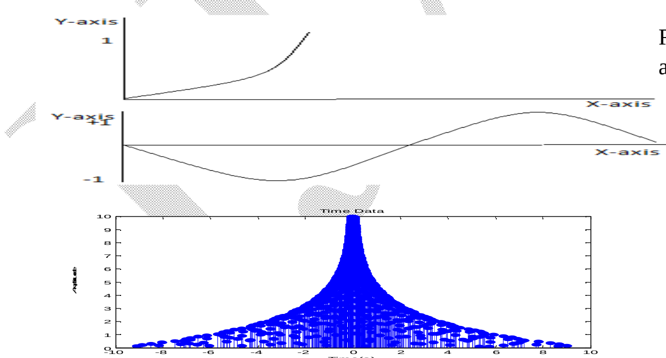


Fig 1: Resultant Exponential Signal

III. DFT ANALYSIS

If you are using *Word,* use either the Microsoft Equation Editor or the MathType add-on (http://www.mathtype.com) for equations in your paper (Insert | Object | Create New | Microsoft Equation *or* Math Type Equation). "Float over text" should *not* be selected. Fourier transform (FT) of infinite length discrete time signal X*n* is defined as

$$X(e)^{j\omega} = \sum_{n=-\infty}^{\infty} X_n e^{-j\omega n} \quad \ldots\ldots\ldots \quad (2)$$

where *n* is integer sample index that goes from minus to plus infinity and *ω* is continuous frequency in radians (angular frequency, pulsation). Continuous spectrum *X*(*ej*) defined by (4) is periodic with the period 2*π*. The notation *X*(*ej*) instead of *X*( ), stresses up the connection between FT and *Z* transform. For finite length discrete time signal *vn* containing *N* samples DFT is defined as

$$V_k = \sum_{n=0}^{N-1} v_n e^{j(2\pi/N)kn} \quad \ldots\ldots\ldots\ldots \quad (3)$$

From it is seen, that by DFT the FT spectrum is computed only for frequencies *k*=(2*π*/*N*)*k*, that is DFT samples continuous spectrum of the discrete signal. Finite length signal *vn*, *n*=0,1,2,...,*N*-1 is obtained from infinite length signal x_n, *n*=...-2, -1,0,1,2,... by windowing, that is by multiplication with discrete signal w_n, called window, with nonzero values only on positions *n*=0,1,2,...,*N*-1

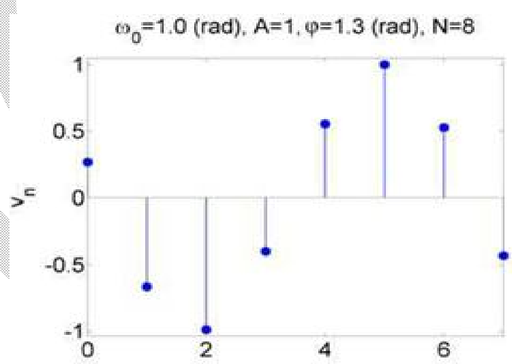
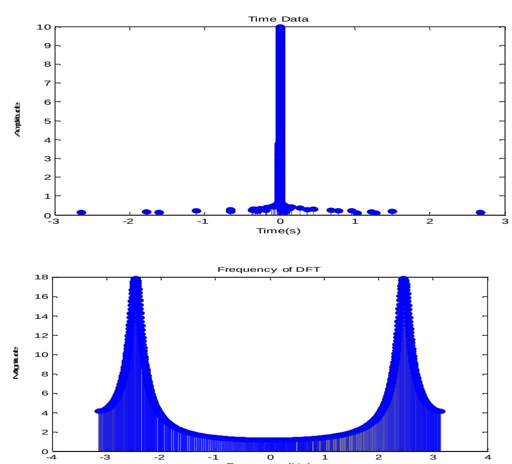


Fig 2 : illustrates equations given above for sinusoidal signal (1) analyzed with rectangular window for A=1, Ø= 1.3 rad, and N =8.

Result obtained from operation done using coding related to DFT algorithm are shown below using some diagrams



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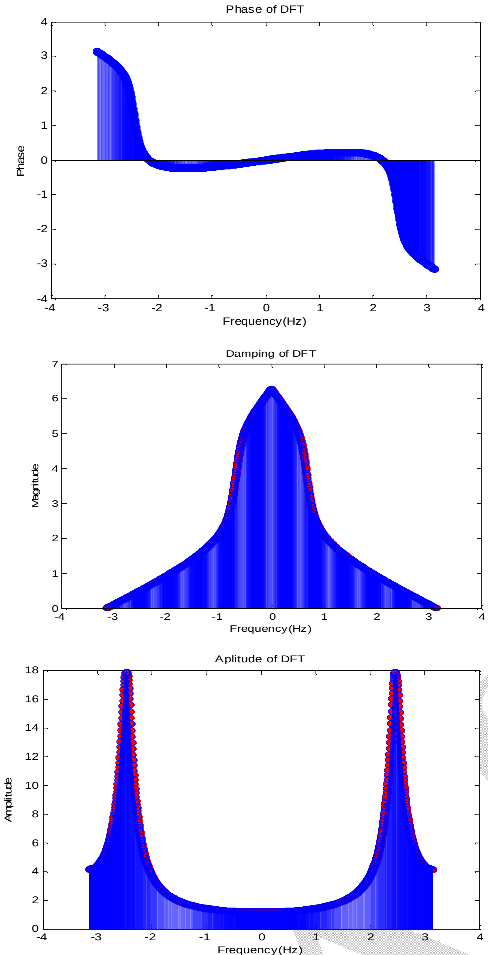

Fig 3 : DFT algorithm Results

IV. INTERPOLATED DFT ALGORITHMS

The IpDFT problem for sinusoidal and damped sinusoidal signals is depicted and may be formulated as follows. Based on the DFT spectrum V_k (5) of the signal x_n analysed with the known window w_n, *FIND* the frequency correction δ so to satisfy the equation

$$\omega_0 = (k \pm \delta)\frac{2\pi}{N}, 0 < \delta \le 0.5 \text{ .... (4)}$$

Where ω_0 is signal's frequency, N is the number of samples and k is the index of DFT bin with the highest magnitude. If $|V_k+1|>|V_k-1|$, as in Fig. Then there is '+'.

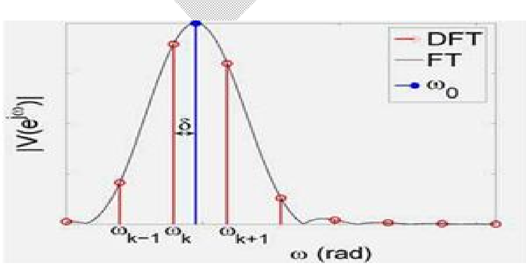

Fig 4 : Illustration Of IPDFT Problem

Result obtained from operation done using coding related to interpolated DFT algorithm are shown below using some diagrams

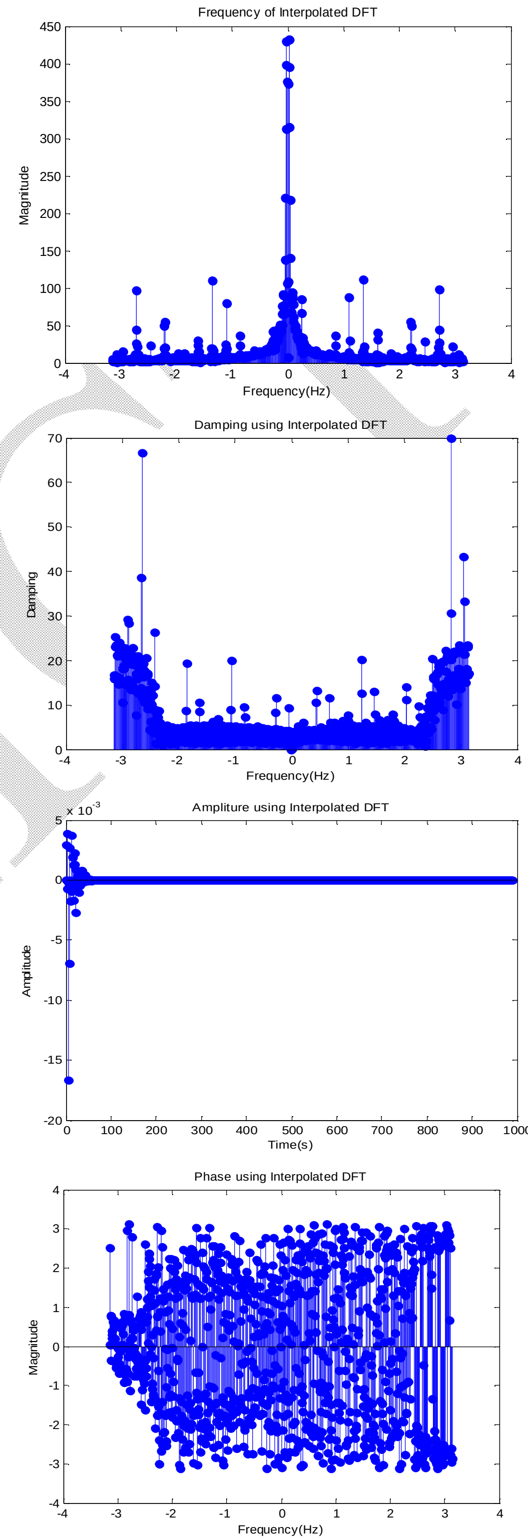

Fig 5 : Results of interpolated DFT algorithm

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V. WINDOWS OUTPUT

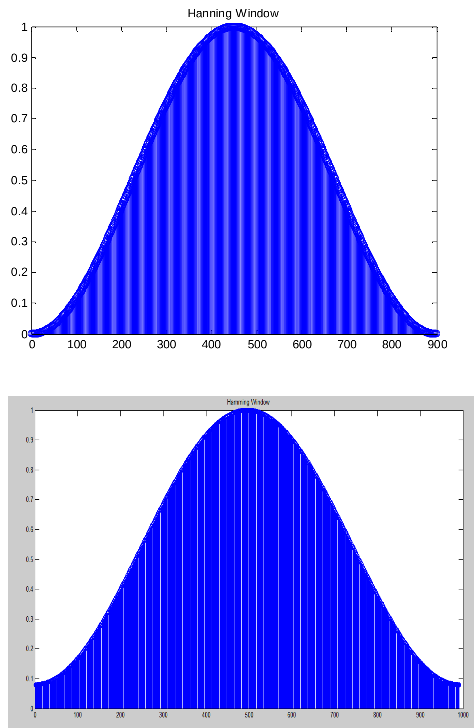

Fig 6 : Output Using Hanning Window

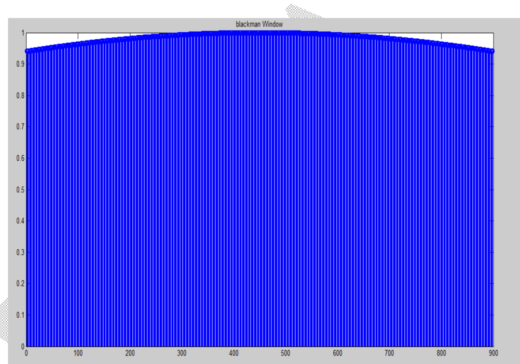

Fig 7 : Output using Blackman Window

Procedure:

There are three major stages in this paper

1) Finding the parameter using different algorithms

2) Comparison between different algorithms

3) Leakage elimination

VI. OUTPUT AFTER LEAKAGE ELIMINATION USING WINDOWS

For calculating leakage elimination factor for resultant signal, here I use the WV Tool i.e. WINDOW VISULISATION TOOLBOX which help us to select a operation with different windows. The WV Tool sees like this,

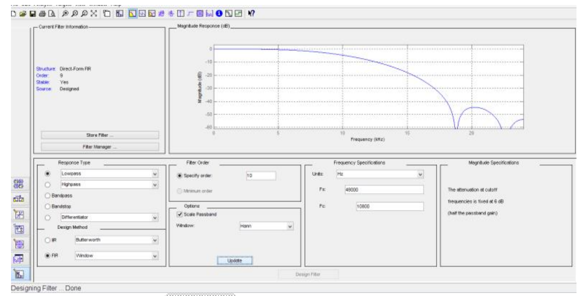

Fig 8 : WV Tool

After applying the output of Hanning, like Hamming and Blackman Windows, the output getting shown below which shows a leakage factor values in percentage.

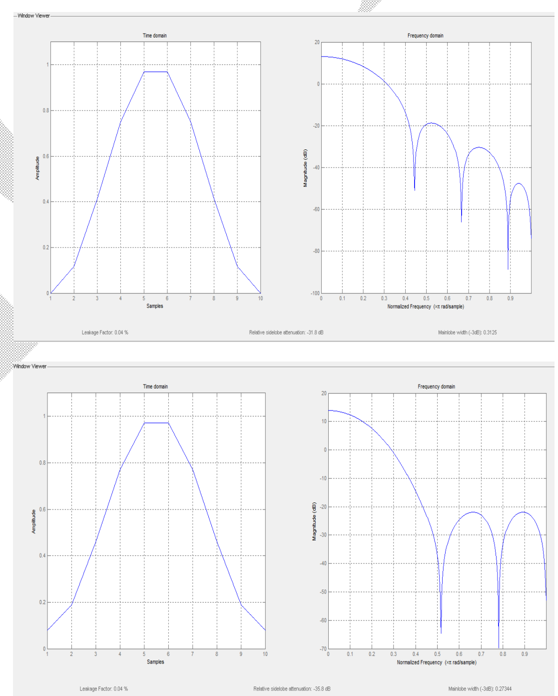

Fig 9 : Hanning Window

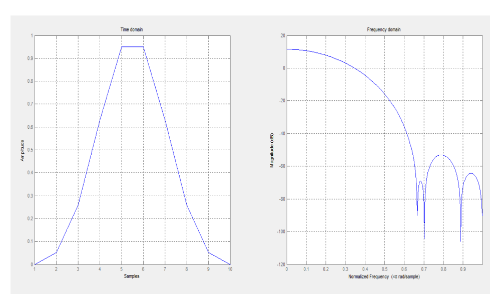

Fig 10 : Blackman Window

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Table 1 : Result Obtained Using Windowing Techniques

Frequency_ham	Damping_hamm	Amplitude_hamm	Phase_hamm
30.53722	0.486947	11.284194	-1.6443
Frequency_hann	Damping_hann	Amplitude_hann	Phase_hann
30.6940	0.4869	11.2842	-1.23244
Frequency_Black	Damping_Black	Amplitude_Black	Phase_Black
29.914	0.4998	10.03994	-1.0365

Following table shows the final comparison between output obtained using three windows and output got from DFT and IDFT.

Table 2: Output from DFT and IDFT

Window↓	Frequency	Damping	Amplitude	Phase
Hamming	30.5372	0.48694	11.28419	-1.6443
Hanning	30.6940	0.4869	11.2842	-1.2324
Blackman	29.914	0.4998	10.03994	-1.0365
IDFT	60.420	10.3421	14.744	0.7854
DFT	61.548	10.95	15.455	1.4878

VII. CONCLUSION

This paper describes leakage elimination process for calculating the parameters frequency, amplitude, damping, phase using different three windows techniques on exponential signal.

Calculated results are shown in upper section which shows the values obtained using windowing techniques are more accurate than the IDFT and DFT algorithms values. And also the value content minimum leakage which is nearly equal to zero. Specially using Blackman Window the values content leakage factor equals to zero.

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