

**Implementation Of Zoom Fft
In Ultrasonic Blood Flow Analysis
- Using Tms320c5x/6x(Code Composer) Dsp Processor.**

ABSTRACT

An adequate blood flow supply is necessary for all organs of the body. Analysis of the blood flow finds its importance in the diagnoses of diseases. There are many techniques for analyzing the blood flow. These techniques are not affordable by the poor people because of their high expense. So we have implemented a technique called Zoom-FFT. This technique is simple and affordable to detect the blood clots and other diseases.

Human with his potential tries to get whichever is unexplored, explored, and till now we are managing and succeeding using some technical ways. In the same way this is one of the explorations made for scanning the intra details of some specific objects using ultrasound named **SONOGRAPHY**, which is used as an alternative to x-ray photography. In this paper, the method to zoom the image or the scanned data-using zoom FFT has been discussed. It also explains the algorithm to get ZOOM FFT and how it can be obtained via simulation. Real time experimentation and its applications, with basics of ultrasound scanning are also explained. Here a specific application will be dealt i.e., ultrasonic blood flow analyzer using **ZOOM FFT**.

Blood flow analysis is done by passing a high frequency ultrasonic wave in the blood vessels through a transducer (transmitter) .The reflected signal; from the receiver transducer has a different frequency due to the Doppler principle. This signal is passed to a DSP processor to find the frequency spectrum. Because of the high frequency of the ultrasonic wave, the resolution of the frequency spectrum output will not be good. Therefore we go for advanced Zoom FFT technique, wherein a very small frequency change due to the clot formation can be obtained with a good resolution. It can be used to

locate the initial presence of a blood clot. All of these tasks must be achieved with a single DSP chip in order for the system to be both cost-effective and power efficient and thus widely accepted.

This paper proposes:

1. Study of Bio-medical signal processing
2. Mixing down the input signal to the base band frequency using Hilbert Transform
3. Finding the down sampling using the decimation process
4. Obtaining the spectrum output using fast Fourier transform
5. Simulation is done by Matlab/C.
6. TMS320C5X/6X DSP processor does real time implementation.

INTRODUCTION

BASICS

“SOUND IS A COMPRESSIONAL WAVE” Sounds at frequencies above the audible range, to say above 20 KHz are Ultrasonic wave, in the megahertz range. Above which are supersonic sound.

DOPPLER EFFECT PHENOMENON

A shift in frequency (f) of the wave will be expected due to the source and observers motion relative to each other. If the distance between them is reduced or increased. That shift in frequency depends on the velocity of sound which also depends on density of the medium, in which it propagates. When a small object is situated in the path of the sound wave, the wave will be resisted (scattered). A direct measurement of this velocity will provide useful information about the dynamic property of the medium. The Velocity of sound in Blood is 1570 m/s. Perceived velocity is $V' = V - V_0$

In terms of frequency (f), as a velocity dependent factor.

$$f_p = \frac{f_0 (V + V_0)}{V - V_s}, \text{ for both objects moving towards.} \quad -(1)$$

$$f_p = \frac{f_0 (V - V_0)}{V + V_s}, \text{ for both objects moving away from each other.} \quad -(2)$$

f_0 : ACTUAL FREQUENCY.

f_p : PERCEIVED FREQUENCY.

V : VELOCITY OF WAVE.

V_s : SOURCE VELOCITY.

V_0 : VELOCITY OF OBSERVER.

Thus we get the perceived frequency proportionately changed with respect to changes in measuring media. This process is explained using animation as below in FIG (1).

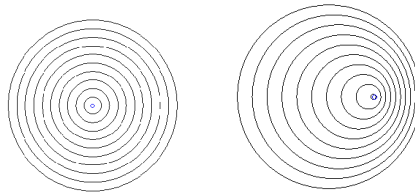


FIG (1).

The Doppler effect can be explained with respect to pitch or wavelength, since all are dependent to each other.

E.g. of Doppler Effect: Say, A car passes you on the street blowing its horn at a frequency of 440Hz, the whole way, As the car approaches you, you will hear a pitch $> 440\text{Hz}$ (in increasing order). After the car passes you and drives away from you, you will hear a pitch lower $< 440\text{Hz}$ (in descending order).

“THIS CONCEPT IS APPLIED IN ULTRASOUND RANGE FOR HUMAN BLOOD FLOW ANALYSIS USING VELOCITY OF BLOOD”

Steps involved:

- ✓ Sound generation: The ultrasonic sound is generated using the **piezoelectric transducer**
- ✓ Number of transducer may vary from 1 to many.
- ✓ Narrow beam of wave is to be feed in.
- ✓ Continuous mode of operation with no timed switching is applied in real time to measure Frequency and Amplitude
- ✓ Doppler shift analysis for frequency content is to be done.
- ✓ Creation of image – to plot in 2 Dimension.
- ✓ Display using color differentiation.

REAL BLOOD FLOW ANALYSIS:

In an Ultrasonic blood flow analysis, a beam of ultrasonic energy is directed through a blood vessel at a shallow angle and its transit time is then measured.. More common are the ultrasonic analyzers based on the Doppler principle. An oscillator, operating at a frequency of several Mega Hertz, excites a piezoelectric transducer. This transducer is coupled to the wall of an exposed blood vessel and sends an ultrasonic beam with a frequency F into the flowing blood. A small part of the transmitted energy is scattered back and is received by a second transducer arranged opposite the first one as shown in Fig(3).

Because the scattering occurs mainly as a result of the moving blood cells. The reflected signal has a different frequency due to a Doppler effect.

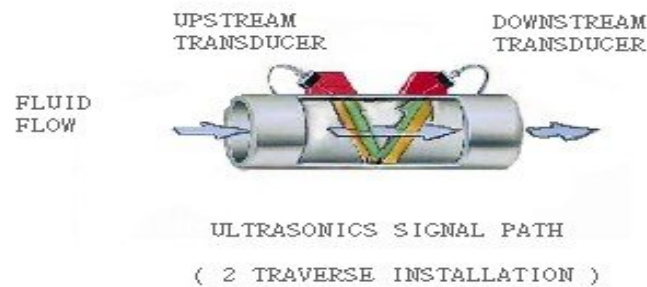
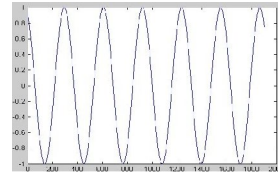
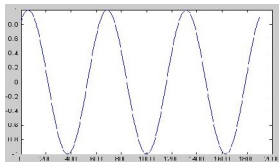


FIG (2).

Placement of transducer

WHY TO ZOOM? Minute variations in blood flow can be seen E.G. (starting stage of blood clot)

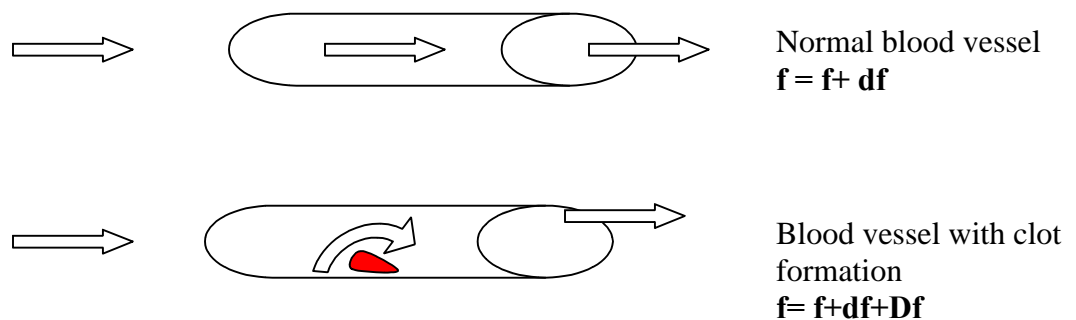


FIG (3).

The variation in the blood flow via, the zoom FFT will be **more evident**,

Practically. This may be in frequency domain or can be imaged in 2D for “**VISUAL PERCEPTION**”.

ZOOM FFT:The Zoom-FFT is a process where an input signal is mixed down to baseband and then decimated, prior to passing it into a standard FFT. The advantage is for example that if you have a sample rate of 10 MHz and require at least 10Hz resolution over a small frequency band (say 1 KHz) then you do not need a 1 Mega point FFT, just decimate by a factor of 4096 and use a 256 point FFT which is obviously quicker.

In contrast, the zoom-FFT uses digital down conversion techniques to localize the standard FFT to a narrow band of frequencies that are centered on a higher frequency. The zoom-FFT is used to reduce the sample rate required when analyzing narrowband signals - E.G. in HF communications.

Zoom FFT analysis is simply an efficient computation of a subset of the FFT. You use this kind of tool when you are mainly interested in a certain frequency band of 10 kHz to 11 kHz. Rather than computing the FFT for the entire frequency range, you only perform computations on a subset of frequencies. Thus, you can save a significant amount of processing power and time using this method.

The following diagram shows the zoom process:

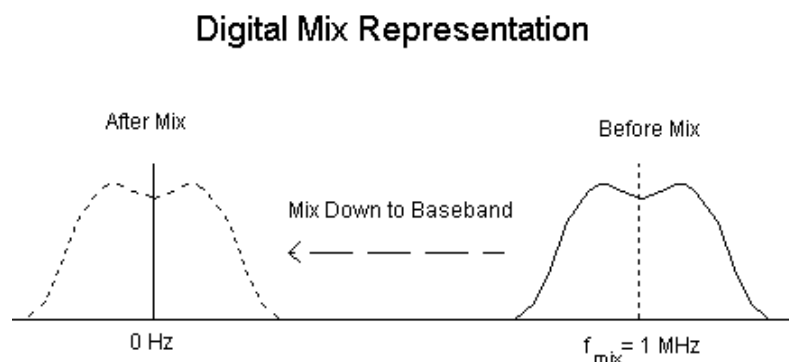
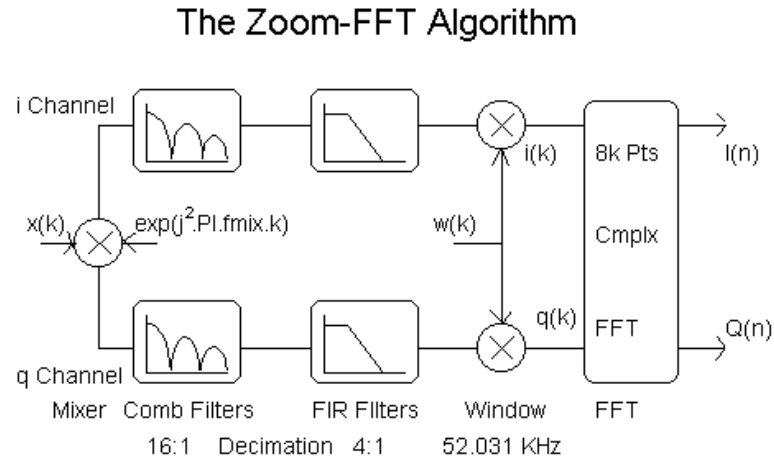


Fig (4)

While the following diagram shows the basic architecture of the Zoom-FFT:



Fig(5)

Spectrum analyzers originally provided the zoom FFT to offer higher frequency resolution over a specific bandwidth, given the limitation of a small amount of on-board memory. With the zoom FFT, you can obtain a very fine frequency resolution (narrow band analysis) without computing the entire spectrum. The ability to increase the frequency resolution of a spectral measurement in part of a frequency range. Zoom can also apply to time domain (oscilloscope) measurements.

Digital zoom (frequency domain) is usually implemented by multiplying the input signal with a sine and cosine at a new desired center frequency, and then low-pass filtering the data, followed by sampling rate reduction (decimation). In contrast, a "visual zoom" simply increases the size of the plot of data without adding any new information.

In traditional FFT Spectrum Analyzers, zoom was implemented in hardware to get around the memory limitations of the processors, which made it impossible to economically perform large Fourier Transforms. However, as memory size and processor speed has increased, large FFT's are now economically possible. Fig (7) shows the difference between FFT and Zoom FFT.

When you need to have high frequency resolution this can be achieved in a number of different ways:

1. Large FFT: Has the advantage that it gives the keeps all spectral lines over the entire frequency range, whereas zoom only picks a sub-set of a given frequency range. Thus with zoom, multiple computations must be made to cover a broader frequency range.
2. Destructive zoom: The traditional zoom method implemented with digital filters, which throw away frequency information outside the selected range.
3. Non-destructive zoom: A zoom technique, which keeps the entire original time function. Thus zoom can be performed in different frequency ranges on the same data without requiring the acquisition of new data.

INPUT SIGNAL: The input signal for the frequency under design can be a cosine wave or a sine wave this periodic is only for the implementation of the work. For real time implementation any non-periodic signal can also be considered.

FREQUENCY TRANSLATION: The signal, which is of high frequency, should be translated to a low frequency to get the proper response of the input signal. This is implemented by frequency translation.

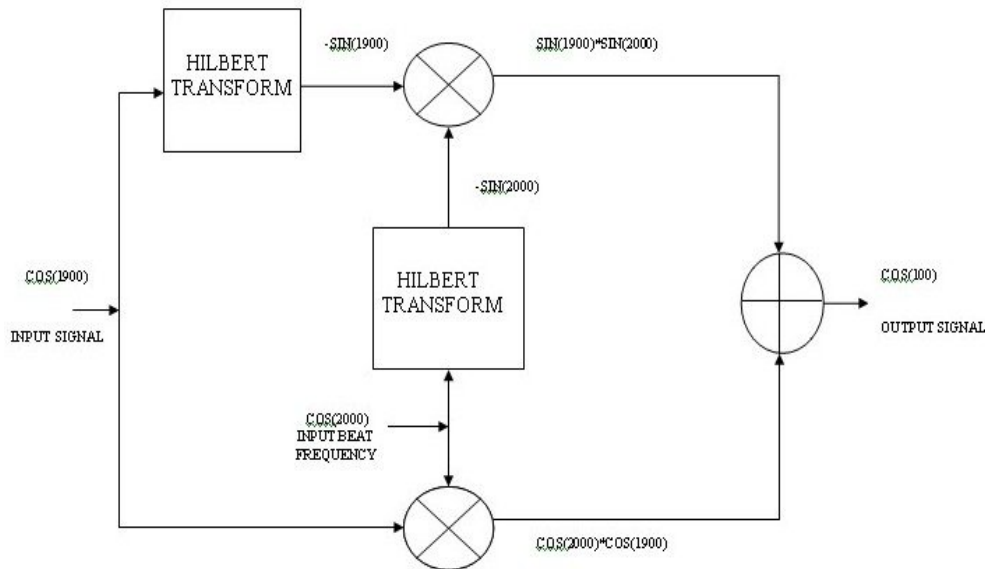


FIG (7).

If $\cos(1900)$ is considered as an input signal it can be translated to $\cos(100)$ by the following procedure as depicted in the figure(7).

The output arrived is as follows,

$$\cos(A-B) = \cos(A)\cos(B) + \sin(A)\sin(B). \quad -(3)$$

$$\text{i.e, } \cos(2000-1900) = \cos(2000)\cos(1900) + \sin(2000)\sin(1900).$$

$$= \cos(100).$$

Thus the input wave, which has frequency 1900Hz, is translated into 100Hz.

Discrete Hilbert Transform formula

The frequency translating function eq-4.

$$N-1$$

$$f(n) = (1/N) \sum_{m=0}^{N-1} [1 - (-1)^{m-n}] f(m) \cot(m-n) (n/N) \quad -(4)$$

$$m=0$$

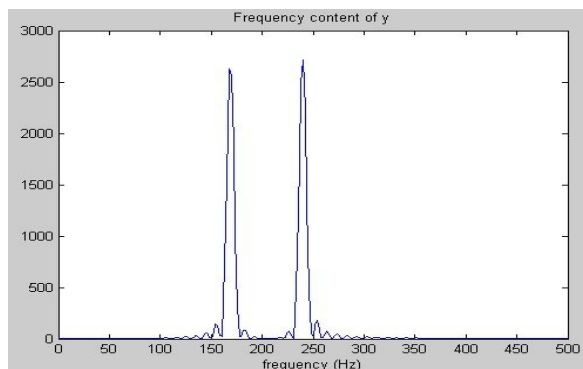
Decimation

Resampling at discrete instances, the already sampled wave. As in eq-5, [1],

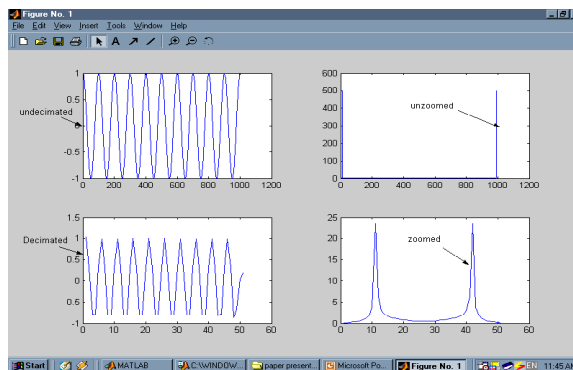
$$Y(m) = \sum_{k=0}^{N-1} h(k)x(Mm-k), \quad M=\text{decimation factor.} \quad -(5)$$

FFT: The Fast Fourier Transform (FFT) is an algorithm that efficiently contains the frequency domain conversion as in Fig (8) and (9).

$$X(k) = \sum_{n=0}^{N-1} x(n)e^{-j2\pi nk/N} \quad 0 \leq k \leq N-1 \quad -(6)$$



FFT of a wave with 2 frequencies
Fig (8).



Fig(9).

SIMULATION RESULTS

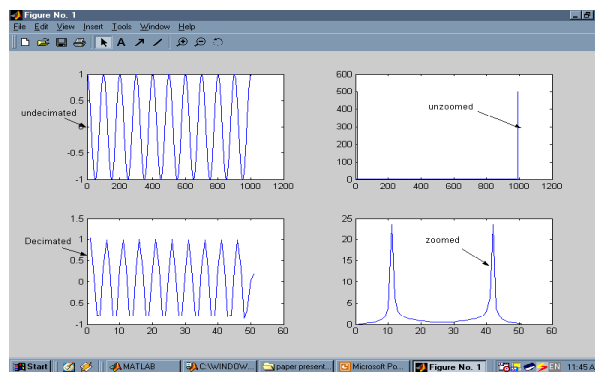
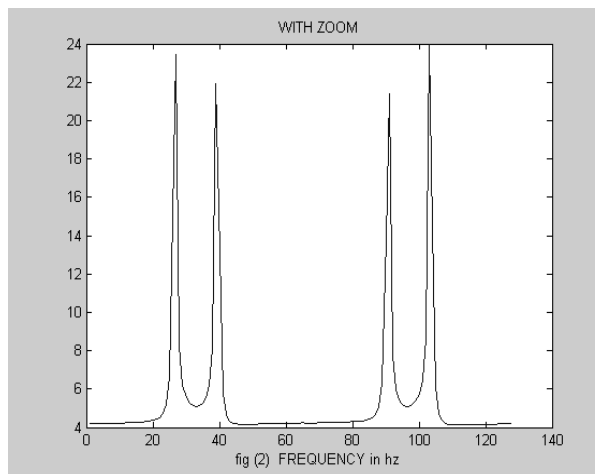
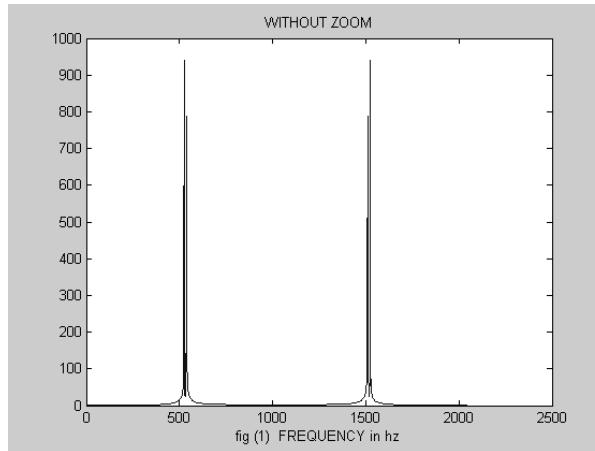


Fig.10. (a) Simulation results without zoom, (b) Simulation results with zoom, (c) Simulation results with zoom/without zoom and input signals.

ADVANTAGES

1. Increased frequency domain resolution
- 2.Reduced hardware cost and complexity
- 3.Wider spectral range

In places where the frequency content has to be analyzed, this zooming FFT can be utilized, mainly for the hidden glitches during signal frequency transition.

APPLICATIONS:

- Ultrasonic blood flow analysis.
- RF communications.
- Mechanical stress analysis.
- Doppler radar.
- Bio-medical fields.
- Side band analysis, and modulation analysis

CONCLUSION

Currently the paper has been tested on the **simulation** basis, the output of the simulations are satisfactory.

Real **time** experimentation is being done, using the piezo electric ultrasonic transducer for verification purpose. The frequencies content from the media are obtained and currently they are being transformed to image as **2D** for visual perception.

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