VIBRATION SIGNAL ANALYSIS FOR MONITORING LAUNCH VEHICLE HEALTH

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Abstract— Vibration signal analysis is an important field in the mechanical industry i.e., vibration is associated with every machine , the analysis of these signals helps in obtaining desired output from the system without much cost of maintenance . Continuous analysis of these signals helps to reduce heavy damage . In this paper uses wavelet analysis for processing the test signal, with the wavelet toolbox feature available in the MATLAB. Using different wavelets the test signal is analyzed and satisfactory results are obtained.

Keywords— Vibration Analysis, Wavelet Transform.

I. INTRODUCTION

We all are familiar with vibrations of different forms, vibrations are mostly harmful for the proper operation of a mechanical system. A launch vehicle experiences different kind of vibrations while transportation, liftoff and due to jet noise, aerodynamic noise. Almost every failures during the satellite launch are caused due to this mechanical vibration and shock. For a launch to be successful the engineers has to make sure that the system must survive the expected vibration environment of the vehicle. Launch vehicle has different stages in launch , this vibrations are compared to previous flight data so as to reduce the chance of damage to the vehicle. This paper deals with the vibration occurred during any stage of launch and analysis of that signal. Here , wavelet signal processing and tool box in MATLAB is used to analyze the signal. Wavelet analysis overcomes all disadvantages caused by other signal processing applications like Fourier transform and Short Fourier transform . Both these above mentioned techniques fail to give the exact scale and position of the occurred vibration in the test signal.

Wavelet signal processing helps to find a sudden change or shock in a signal , this property makes it different from other signal processing techniques. In wavelet signal processing the mother wavelet is scaled and shifted along the length of the test signal to analyze it. Thus the time and frequency information of the test signal can be found out .

II. NON - STATIONARY SIGNAL ANALYSIS

The signals can be classified as stationary and non-stationary, mostly vibration signals are non-stationary. A signal that changes at every instant of time is called non-stationary signal and the one that does not change with respect to time is called as stationary signal. Here in this paper we deal with non-stationary signals as the test signal. Fourier Transform is one of the basic method used for the analysis of the signal , the accurate time information is lost in this case . For a set of similar frequency signal only one frequency coefficient is obtained as an output from the Fourier analysis. Thus FT is not considered as a good method for finding out the vibration in a signal.

An advanced version of Fourier transform with a window function is called Short Time Fourier Transform (STFT) , but here the problem is that the window size is constant . Once a window size is chosen , then the time - frequency resolution is fixed for the entire plane . This is the drawback of the STFT method of analysis.

To overcome the multi resolution issue of the STFT , wavelet transforms are used which helps to obtain multiple resolution in time-frequency plane which made multi resolution analysis more easy. Here in wavelet analysis a mother wavelet is taken and is scaled and shifted along the time- frequency axis to analyze the test signal. The wavelets used can be Haar, Daubechies, Morlet etc. Wavelet transforms like continuous wavelet transform and discrete wavelet transforms are used in the wavelet analysis .

III. METHOD OF IMPLEMENTATION

Wavelets are irregular in shape and compact. It is this property of wavelet makes them an ideal tool for analyzing signals of non-stationary nature. This irregular shape helps to locate any sharp changes in the signal and the compact shape helps to localize the signal features. Wavelet transforms are used here to identify the vibration that may cause trouble to the proper working of the launch vehicle.

The two transforms which is used in the paper are continuous and discrete wavelet transform and also the wavelet toolbox feature in MATALB is used . This toolbox is the simplest method to identify the shock or sudden change in the test signal. In the toolbox the test signal is loaded and required wavelet is chosen , on completion of the analysis the output plot shows wavelet coefficients . The coefficient with

the highest amplitude is our point of interest or the position were a vibration has occurred. The output plot can easily show the position in the test signal where the vibration or the shock is identified.

3.1 Wavelet Transforms

Continuous and discrete wavelet transforms are used , both performs well in identifying the vibration in the test signal. Test signal is loaded and a wavelet of an order is chosen for analyzing the signal. The mother wavelet is shifted and scaled throughout the signal and the coefficients are calculated ,which is the correlation of the wavelet to the test signal . And if the shift and scale is done as power of two then the analysis is DWT (dyadic scale), whereas for the continuous wavelet transform the shift and scale is smooth across the signal length. DWT acts as a filter (both low and high pass filter) which helps to get finer details of the testing signal. If the signal needs to be reconstructed then DWT can be used , whereas CWT does not produce the exact original test signal.
The test signal is shown in the figure 1, this signal is assumed to be a launch vehicles flight data .

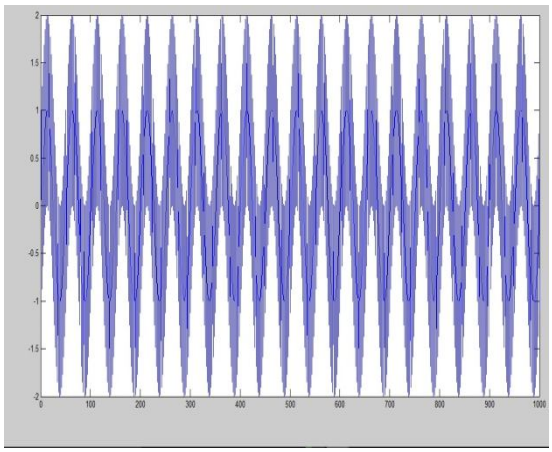

Figure 1. Test signal

After the analysis is done the vibrations are located in the coefficient plot which is shown in the figure 2. The analysis is done by correlating the test signal with the wavelet here Haar wavelet coefficients are used as filter coefficients . The output thus obtained is shown below.

IV. RESULT AND CONCLUSION

Thus with the help of this wavelet transform the sudden changes in a signal can be easily found out i.e., continuous and discrete wavelet transform with required wavelet . This vibration signal analysis will help in any mechanical system to identify the intensity or magnitude of the vibration that may cause heavy damage to the respective system. This method will also be a huge success in gearbox system of a vehicle and even to identify the intensity of an earth quake.

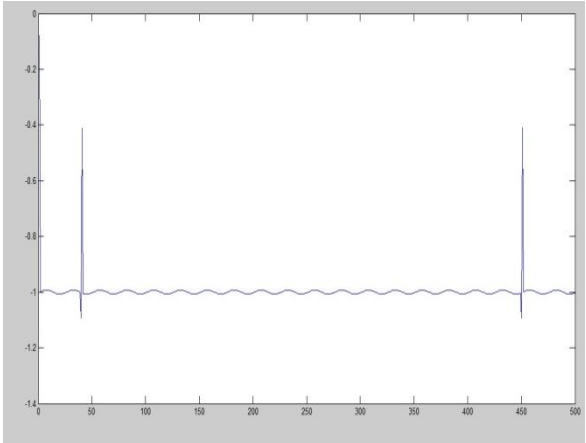

Figure 2. Output

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