The Role of DC Component and Trend Term in FFT Transform Spectrum Analysis

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Abstract. Most of the actual signals are analyzed and processed with zero spectral line values. This paper describes the causes of this phenomenon and the solutions. Through the analysis of a group of specific experimental data, the N-point FFT transform is carried out. By observing the original data and the frequency-shifted spectrum, the original can be intuitively understood. The signal has strong DC component and trend term (trend term is also divided into linear trend term and polynomial trend term). Because of this, the frequency spectrum obtained by FFT is mostly zero. In this paper, the DC component of the signal is calculated and the trend term is eliminated by using the digital signal processing function of MATLAB, and the whole spectrum is obtained. Finally, the specific area is selected according to the actual requirements. The spectrum analysis was carried out to obtain the qualified spectrum.

1. Introduction
FFT [1] is an important part of digital information processing technology [2-3]. With the development of large scale integrated circuit [4], FFT will be applied more and more widely, which makes it possible to solve complex signals with the help of computers. Therefore, the correct acquisition of spectrum is the first step in spectral analysis [5], and also an extremely important step in FFT transformation. However, due to the practical operation, the application of FFT will be more and more extensive. In the process, some negligence may lead to some erroneous spectrograms. Most of the spectrograms obtained by FFT analysis and processing of many actual signals are zero. Many people do not realize that this is the wrong spectrogram, let alone analyze the reasons for this phenomenon, but solve it directly downward, resulting in a step-by-step error, and do not get the desired result. With the correct results, the next article will analyze the causes of this phenomenon and its solutions.

2. Question: After FFT processing, most of the spectral line values in the spectrum are zero.

2.1. Specific simulation process
After FFT transform, it is found that a large part of the spectrum becomes zero, and this kind of problem also occurs in the actual signal analysis.

Next, I use the experimental data set [6] for FFT transformation and simulation to find the reasons for this phenomenon. The simulation results are as follows: Fig. 1
2.2. Simulation Analysis
From the figure 1, we can clearly see that the time-domain signal is disorderly, but on the whole, there is a clear upward trend and there is almost nothing in the amplitude-frequency characteristic curve. There are many frequency components with small amplitude on the frequency axis, which can be approximated to zero on the whole amplitude-frequency characteristic curve.

3. Specific treatment methods
Fig 1-1 is processed as follows to obtain Fig. 2. The specific process is as follows:

3.1. DC component
If we only consider the theoretical analysis, Fig. 2 expands the amplitude-frequency characteristic curve of the frequency axis to -10Hz, which shows that there is a large DC component at 0 frequency and other frequencies are very small.

3.2. Trend Term
If the original signal is linearly fitted, the linear fitting equation can be obtained [6]: \( y = 2.3x + 5.1 \). It can be seen that the original signal has a linear upward trend.

3.3. Result
By observing the original data and its frequency shift spectrum, we can intuitively understand that the original signal has strong DC component [7-8] and trend term [9-12] (trend term is also divided into linear trend term [11] and polynomial trend term [12]), which is why most of the spectrum obtained by FFT is zero.
4. Problem Solutions

In order to obtain better spectral analysis, the DC component and trend term should be eliminated for any set of data sequences. Trend term can be divided into linear trend term and polynomial trend term. Elimination of linear trend term is discussed here.

In MATLAB, the DC component is calculated by means function [13-14], and the linear trend term is eliminated by detrend function [13-14]. Fig. 3 is obtained by FFT transform again.

It can be seen from the first picture of Fig. 3 that after eliminating the DC component and the linear trend term, the time-domain signal fluctuates in an interval without a clear upward trend. In the second picture, it can be seen that the amplitude-frequency characteristic curve does not only have a larger frequency component at the origin as in the second picture of Fig. 1, but has a frequency component
in the whole frequency range, which solves the problem well. The problem that the useful signal is shown to be zero in the whole frequency domain due to the excessive local frequency component.

5. Conclusion
In the process of spectrum analysis and FFT transformation of signals, it is necessary to have a general understanding of the initial signal. If the original signal is processed by FFT transformation and spectral analysis, it is necessary to know how much the area of interest can affect the whole project. Whether only a part of the signal data needs to be selected for analysis, so as to avoid the submergence effect of the whole signal, and whether the data itself has a strong trend and a large DC component leads to the near-zero amplitude in the spectrum after FFT. Therefore, before doing spectral analysis, the data to be analyzed should be displayed and observed to understand the range of the signal amplitude and other general parameters, so as to decide whether to pre-process the original signal, such as when the original signal is processed. The direct current component and trend term (linear trend term and polynomial trend term) of the signal should be eliminated firstly when FFT transform is used for spectral analysis. Only after these pretreatments can the correct spectrum be obtained.

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