Experiment 5B

Spectrum Analysis

Introduction

Experiment 5B: Spectrum Analysis by Fast Fourier Transform Implementation on TMS320C5515 Kit

The aim of this experiment is to implement spectrum analysis by Fast Fourier Transform (FFT) on TMS320C5515 kits. At the end of the experiment, students will test their implementation on the audio signals which were provided in Experiment 3A.

Theoretical Information

In digital signal processing, analog signals are sampled in time and converted to digital signals. What we usually have in our hands is a vector of signal values in which the indices of the vector are in time domain. In short, what we see is the value of the signal at the specific instant of time. We can easily observe the behavior of the signal with respect to time using the oscilloscopes. But sometimes, observation only in time-domain may not provide us enough information where spectrum analysis, or analysis of the signal in frequency domain comes to the scene. By spectral analysis, we can obtain the frequency components of the signal as shown in Figure 1.

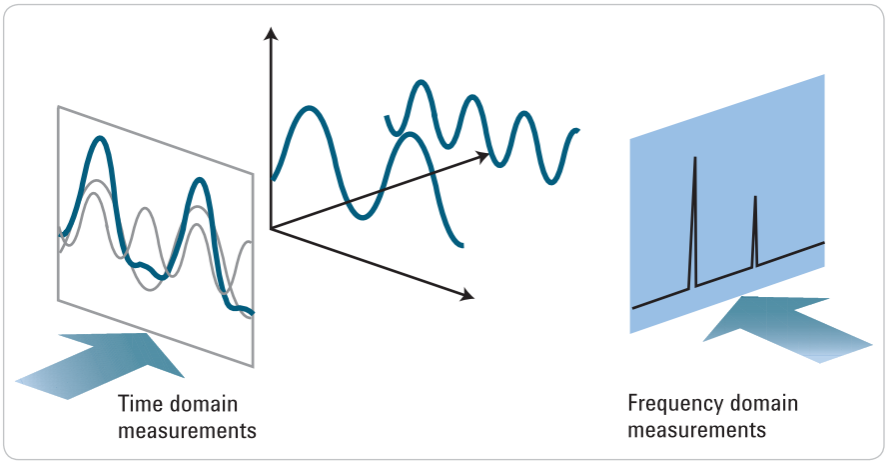

Figure 1: Time-domain and frequency-domain relationship (source: http://cp.literature.agilent.com/litweb/pdf/5952-0292.pdf)

Fast Fourier Transform (FFT) is used to convert a signal from time-domain to frequency domain. Discrete Fourier Transform (DFT) is used to for Fourier Transformation of the signals which consist of discrete-time samples. DFT can be calculated by:

$$X[k] = \sum_{n=0}^{N-1} x[n] e^{-j2\pi \frac{k}{N} n}, k = 0,1,...N-1$$

where:

k: index of the frequency,

n: index of the discrete time,

$x[n]$: value of the signal at time n,

N: number of samples we have,

$X[k]$: amount of frequency k in the signal (amplitude and phase, a complex number).

If we use the Euler's formula ($e^{inx} = \cos(nx) + i \sin(nx)$), then we can write every X[k] in terms of its real and imaginary parts as follows:

$$X[k] = X_{re}[k] + j X_{im}[k]$$

$$X_{re}[k] = \sum_{n=0}^{N-1} x[n].\cos(\frac{jkn2\pi}{N})$$

$$X_{im}[k] = -\sum_{n=0}^{N-1} x[n].\sin(\frac{jkn2\pi}{N})$$

Before the Experiment

1. Review Fourier Theory, Fourier Transform and DFT.

Experiment 5B.1

Take a limited length sine wave created by function generator as input. Implement the DFT on TMS320C5515 kit using the given information.

Experiment 5B.2

Using the Memory Browser toolbox of Code Composer Studio, save the obtained sine wave and its real and imaginary parts. Using csvread function of MATLAB, read these data and plot them. Use MATLAB's fft function on the signal and compare it with your findings.

Report

1. Prepare your report in a suitable format.