

Laboratory 3A:

**Fourier Transformation and FFT**

In this laboratory you experiment with some properties of the Fourier Transformation, plus you observe the spectrum changes between periodic and aperiodic signals, and gather further experience with applications of the numerical algorithm Fast Fourier Transformation (FFT).

**Exercise 1: Duality Property of the Fourier Transformation**

1. Set the function generator TTI TG5011 to output a periodic pulse with the form of a sinc function. Observe the signal in the time domain, using the oscilloscope and note down the following characteristics: frequency, period, and width of the 1st lobe.

*Tip: Select in the signal generator >Arb >Load >BuiltIn1 > Sinc*

1. Observe now the signal in the frequency domain, using the FFT of the oscilloscope, and note down the following characteristics: shape of the spectrum, fstep (distance between harmonics).
2. Check now the description of the duality property of the Fourier Transformation (in chapter 3 of the script), and compare to the characteristics you noted in items (a) and (b). Can you explain the correspondences you observe here? How can you confirm this duality property?

**Exercise 2 : Transition from Fourier Series to Fourier Transformation**

1. Set the function generator TTI TG5011 to output a pulse signal s(t) with a width tau,   
   (take τ = 1 ms ), and a period T0, or corresponding fundamental frequency f0 = 1/T0 varying from 500 Hz, 200 Hz, 100 Hz, 50 Hz down to 10 Hz.

*Tip: Use the menu > Pulse, and settings PlsFrq and Width*

1. Observe the output signal in the time domain first. Then switch to the *>Math>FFT* function and observe the corresponding spectrum (signal measured in the frequency domain).
2. What happens in the frequency domain as the fundamental frequency of s(t) decreases?
3. What happens with the position of the zero crossings of the spectrum as you change the fundamental frequency of s(t).
4. Which parameter determines the value of the zero-crossings? Check your supposition by changing the width tau (for example take τ = 2 ms).
5. The property you observe here is called: Time-Scaling or Time-Bandwidth product. Confirm this property by calculating for 2 values of tau the time-Bandwidth product. You can take as bandwidth in the frequency domain the value of the 1st zero-crossing of the spectrum.

Tip: you can visualize the zero crossings better by selecting f0 < 50Hz.

**Exercise 3** *Tchin-Tchin: Synthesis of a Glass-Sound.*

In this exercise you analyze and synthesize a copy of a given glass sound.

Take the recorded sound example in file *Glas.mat*, and conduct the following steps:

* Analyze the audio signal in the recorded sound-file using the FFT;
* Generate a plot of the audio signal in time and in frequency domain;
* Complete the Matlab script, which synthesizes the glass-sound by adding up the few dominant frequency components, and weighting the signal with an envelope in the time domain.

Tip-1 : Use the exp() function to implement the envelop curve;

Tip-2 : The file *sisy1\_lab3A\_exer\_synthesis.m* is available as a start point.