Laboratory report

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| Subject of the exercise: | Frequency domain analysis (Exercise 4.) |
| **Date:** | <year>. <month>. <day> |
| **Location:** | BME, Q.BP107 |
| **Students name:** | <name 1>  <name 2> |
| **Group and Desk No.** | Group <No.>, Desk <No.> |
| **Supervisor:** | <name> |

Measurement instruments

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| --- | --- | --- |
| Digital multimeter | Agilent 34401A | <Serial No.> |
| Power supply | Agilent E3630 | <Serial No.> |
| Function generator | Agilent 33220A | <Serial No.> |
| Oscilloscope | Agilent 54622A | <Serial No.> |
| Test board | VIK-05-01 |  |

Laboratory Exercises

1. Spectral analysis using FFT

In this task we get acquainted with the use of the FFT function of the oscilloscope. Save the plots from the oscilloscope and explain your findings.

The first task should be performed without using a window function. This can be set in the FFT menu by choosing a Rectangular window in Settings-> More FFT-> Window. The FFT display can be scaled in the X direction in the FFT Settings->Span and Settings-> Center menu. Using a Span of 20 kHz and a Center of 10 kHz is a good starting point. The display can be shifted and scaled in the Y direction in the Settings->More FFT menu with the Scale and Offset parameters.

* 1. Set a 1 kHz square wave on the function generator and observe the spectrum using the oscilloscope in the case of computing the FFT from one period only. (This can be set using the time-base of the oscilloscope: the instrument computes the FFT from the displayed part of the signal.) Observe how the spectrum changes when it is computed from more whole periods (eg. exactly 10 periods). Which one of the two spectrum plots look more similar to the one expected from theory? What is the reason for this? Calculate the resolution of the FFT (Δf) in both cases.

comments, observations>

* 1. Now set a sine wave on the function generator, and tune the frequency so that the spectral leakage is maximal by computing the FFT from 10.5 periods of the signal. (This is achieved by setting 1.05 kHz frequency.) The amplitude of the sine wave should be set to 1 VRMS. Measure the amplitude of the sine wave by using the cursors on the spectrum figure and compare it with the theoretically expected value. Repeat the measurement using Hanning and Flat Top windows. (Settings-> More FFT-> Window menu.) Explain why the amplitude measurement is improved by using the different window functions. What differences can you observe in the shapes of the spectral peaks depending on the choice of the FFT window?

<comments, observations>

* 1. By using the sine wave set in the previous task, observe how the spectrum is changed when the input of the oscilloscope is overdriven. This can be set by choosing the input sensitivity in such a way that the peaks of the sine wave are clipped in the time-domain plot. Explain your findings.

(Note: this task shows that during spectrum analysis the time-domain plot should always be checked in order to assure that the input signal does not get distorted. By omitting this we might overdrive the input channel which leads to wrong measurements.)

<comments, observations>

1. Spectrums of various signals

Generate sine and square waves by using the function generator. Display the spectrums of these signals on the oscilloscope by the built-in FFT function.

* 1. Measure the first 10 harmonics of the sine and square wave signals and compare them with the theoretical values. What are the differences? What is the reason?

Let the amplitude be 2 Vpp in every case. The output load of the function generator should be set to high impedance, otherwise the displayed values on the generator and the oscilloscope are different. It is worth noting that the oscilloscope displays the result of the FFT in dBV which means that the reference is a sine signal with amplitude 1 VRMS.

<measurement setup>

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| f/f0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| U [dBV] measured |  |  |  |  |  |  |  |  |  |  |  |
| U [dBV] *theoretical* |  |  |  |  |  |  |  |  |  |  |  |

<comments, observations>

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| f/f0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| U [dBV] measured |  |  |  |  |  |  |  |  |  |  |  |
| U [dBV] *theoretical* |  |  |  |  |  |  |  |  |  |  |  |

<comments, observations>

* 1. Change the duty cycle of the square wave. What does it cause in the spectrum?

Note: low value for duty cycle can be set in the Pulse menu. Observe the spectrum at some particular duty cycle values, such as 5, 10 and 20 %. Which harmonics are missing from the spectrum?

<comments, observations>

* 1. Study the spectrum of a noise signal. Examine the differences compared to the periodic waves.

<comments, observations>

1. Analysis of Low-pass and High-Pass Filtering

Determine the effects of low-pass and high-pass filtering in the time and frequency domain, respectively.

* 1. Use the first order low-pass filter of the test board. By applying square wave excitation examine the input and output signal in time- and frequency domain, respectively. Let the frequency of the square wave be approximately 10 times smaller than the theoretically calculated cutoff frequency of the filter. What do you observe? Explain the results.

<comments, observations>

* 1. Repeat the previous exercise using a high-pass filter on the same board. Let the frequency be approximately 10 times smaller than the cutoff frequency of the filter. What is the effect of the filter on the square wave?

<comments, observations>

1. Measuring the amplitude characteristic by applying high bandwidth periodic signals

Measure the amplitude characteristic of the first order low-pass filter on the board in one step. The parameters of the filter (values of the resistors) can be set up by the switch.

* 1. Estimate the cutoff frequency of the first order low-pass filter by examining the input and output spectrums. The excitation signal should be a periodic sinc wave (Arb->Select Wform->Built-In-> Sinc menu on the function generator). Set the frequency of the sinc function around 10 times smaller compared to the theoretically expected cutoff frequency.

Compare this kind of measurement method with the stepped sine measurement used in the 4th laboratory “Time domain alalysis”. What are the advantages/drawbacks of the different methods?

<comments, observations>

* 1. Use noise signal as excitation. Measure the amplitude spectrum of the output.

<comments, observations>