Laboratory report

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

Measurement instruments

|  |  |  |
| --- | --- | --- |
| Power supply | Agilent E3630A | <Serial No. |
| Function generator | Agilent 33220A | or label> |
| Oscilloscope | Agilent 54622A | < S. No > |
| Multimeter |  |  |

Laboratory exercises

1. Measurement of time domain parameters of signals
   1. Build a first order low-pass and a high-pass filter using a breadboard, capacitor and resistors. Investigate the step response of the first order low- and high pass filters with three different resistor values using a 100 Hz square wave excitation signal. Document the tendency you see by changing the resistor value of the RC filters and explain what is the reason.

<your observations>

* 1. The next exercises should be accomplished either using the passive low- or the high-pass filter, depending on the instruction of your tutor.

kind of filter selected by your tutor (low-pass/high-pass):

capacitor and resistor values and the calculated time constant:

* + 1. Apply a 100 Hz square wave to the input of the filter, and investigate the wave shapes on the oscilloscope. The output impedance of the generator is 50 Ω, thus, it cannot be considered as ideal voltage driven generator. Investigate therefore also the input signal of the filter, and check how close it is to an ideal square wave.

<your observations>

* + 1. Give a rough estimate for the time constant of the filter based on the tangent at the zero point.

<your observations>

* + 1. Estimate the time constant of the filter based on the time the step response reaches the 50% of the final value.

<your observations>

* + 1. If you have a low-pass filter: estimate the time constant of the filter based on the time at which the distance between the signal actual value and the final value decreases by a factor *e* relative to the final value.

If you have a high-pass filter: estimate the time constant of the filter based on the time at which the signal actual value decreases by a factor *e* relative to the zero value (value at time 0).

<your observations>

* + 1. Compare the results of the time constant estimates based on different methods. Which are more accurate than others?

<your observations>

* 1. Study the behavior of the oscilloscope in the case of a very low frequency square wave. Check the effect of switching between AC and DC coupling. What is the reason for the difference?

<your observations>

* 1. Measure a very high frequency square wave in the time domain (the highest that can be set on the function generator). What is the difference compared to the ideal square wave? Why?

<your observations>

1. Transfer function measurement using time domain methods
   1. Measure the magnitude and phase responses of the passive low- or high-pass filter using a sinusoidal excitation signal according to the exercises below!
      1. Measure the phase response of the filter at the theoretically computed cutoff frequency by two different measurement methods: (a) measurement of time delay and period time with oscilloscope, (b) phase measurement with the automatic measurement functionality of the oscilloscope (Quick Measure function).

<your observations>

* + 1. Measure the magnitude response (attenuation) of the filter at the theoretically computed cutoff frequency by two different measurement methods: (a) by measuring the RMS value of the input and output using the Quick Measure function of the digital oscilloscope and computing the attenuation in dB by the logarithmic formula, and (b) by using the dB function of the digital multimeter directly. By finetuning the excitation frequency, find the real cutoff frequency (-3 dB point) of the filter.

<your observations>

* + 1. Measure the magnitude and phase responses of the filter at seven different frequencies, at 1/10, 1/5, 1/2, 1, 2, 5, and 10 times of the cutoff frequency! For the phase measurement the Quick Measure function of the oscilloscope should be used, for the magnitude the dB function of the digital multimeter should be applied. (Collect the results in an Excel table and create the corresponding charts – set the x axis to logarithmic scale! Copy the table and the charts below.)

The measured magnitude response:

The measured phase response:

<your observations>

1. Investigation of reflection on a coaxial cable
   * 1. Investigate the reflection of signals on a coaxial cable! Apply a periodic pulse wave to the cable. Set the shortest pulse signal on the function generator as an excitation signal, and investigate the reflection by applying different loads (short circuit, open circuit, matched load) to the far end of the cable. Display the signals of both the near and far end of the cable simultaneously on the digital oscilloscope! Document the wave shapes and your observations.
     2. Investigate the reflection with a step signal: set a square wave on the function generator as an excitation signal, and investigate the reflection by applying different loads (short circuit, open circuit, matched load) to the far end of the cable! Display the signals of both the near and far end of the cable simultaneously on the digital oscilloscope! Document the wave shapes and your observations.

<your observations>

Additional Laboratory Exercises

1. Averaging as noise suppression
   1. Get acquainted with the averaging function of the oscilloscope. Generate a noisy periodic signal! The signal-to-noise ratio can be made worse the most easily by reducing the amplitude of the signal generator (setting a very low signal amplitude, at which the signal level is comparable to the level of the ambient noise). Set the function generator to produce a periodic triangular waveform with 1 kHz frequency and 100% symmetry, and reduce the amplitude to the least possible value (20 mVpp peak-to-peak)! Trigger the oscilloscope to the rising edge of the waveform.
      1. Investigate the waveform without and with averaging! Use the SYNC output of the function generator as the trigger source! Measure the peak value of the signal in both cases.

<your observations>

* + 1. Accomplish the averaging first by using the noisy waveform as trigger source, then by using a noise free source (SYNC output of the signal generator). What is your observation?

<your observations>

* + 1. Repeat the previous measurement with square wave signal! What is your observation?

<your observations>