LABORATORY OF ANALOG LINEAR CIRCUITS

Laboratory exercise no.: **1C**	Consecutive protocol number:	Name and surname: 1. 2. 3.

Title: Examples of application of the operational amplifier

Day of week:	Date of the measurements:	Date of the elaborations:	**Grade:**

5.1.1. Measure amplitude characteristics of low-pass filters, $K_u = V_{wy}/V_{we}$.

Choose the circuit according to table (e.g. F1), set the circuit (macro) parameters, write configuration data to FPAA (Ctrl + W), set the generator waveform amplitude to V_{we} = 100 mV and measure filter output voltage as a function of frequency according to the table.

Choose circuit F1 **Set:** G=1 V/V, Q=0.707, f=10kHz				**Choose circuit F2** **Set:** G=1 V/V, Q=10, f=10kHz			
f [kHz]	V_{wy} [mV]	K_u [V/V]	$20 \cdot \log\lvert K_u \rvert$	f [kHz]	V_{wy} [mV]	K_u [V/V]	$20 \cdot \log\lvert K_u \rvert$
0.5				0.5			
1.0				1.0			
2.0				2.0			
3.0				3.0			
4.0				4.0			
5.0				5.0			
6.0				6.0			
7.0				7.0			
8.0				7.5			
9.0				8.0			
10.0				8.5			
14.0				9.0			
16.0				9.5			
18.0				10.0			
20.0				10.5			
30.0				11.0			
40.0				11.5			
				12.0			
				13.0			
				14.0			
				16.0			
				18.0			
				20.0			
				30.0			
				40.0			
f_{H3dB} [kHz]							

Plot the measured frequency characteristics of filters 20log|K_u| as a function of frequency (vertical axis: logarithmic horizontal axis logarithmic) on single graph.

Remark!

For low-pass filters f_{H3dB} – upper 3 dB cutoff (corner) frequency $K_u(f_{H3dB})$ = 0.707 is defined.

For high-pass filters f_{L3dB} – lower 3 dB cutoff frequency $K_u(f_{L3dB})$ = 0.707 . is defined.

For band-pass filters both lower an upper 3dB cutoff frequencies are defined.

5.1.2. Measure amplitude characteristics of high-pass filters, $K_u=V_{wy}/V_{we}$.

Choose the circuit according to table (e.g. F3), set the circuit parameters, write configuration data to FPAA (Ctrl + W), set the generator waveform amplitude to V_{we} = 100 mV and measure filter output voltage as a function of frequency according to the table.

Choose circuit F3 **Set:** G=1 V/V, Q=0.707, f=10kHz				**Choose circuit F4** **Set:** G=1 V/V, Q=10, f=10kHz			
f	V_{wy}	K_u	$20\cdot\log\lvert K_u\rvert$	f	V_{wy}	K_u	$20\cdot\log\lvert K_u\rvert$
[kHz]	[mV]	[V/V]		[kHz]	[mV]	[V/V]	
2.0				2.0			
4.0				3.0			
6.0				4.0			
8.0				5.0			
10.0				6.0			
11.0				6.5			
12.0				7.0			
13.0				7.5			
14.0				8.0			
15.0				8.5			
16.0				9.0			
17.0				9.5			
18.0				10.0			
19.0				10.5			
20.0				11.0			
25.0				12.0			
50.0				13.0			
100.0				14.0			
				16.0			
				18.0			
				20.0			
				25.0			
				30.0			
				50.0			
				100.0			
f_{L3dB} [kHz]							

Plot the measured frequency characteristics of filters 20log|K_u| as a function of frequency (vertical axis: logarithmic horizontal axis logarithmic) on single graph.

5.1.3. Measure amplitude characteristics of band-pass filters, $K_u=V_{wy}/V_{we}$.

Choose the circuit according to table (F6), set the circuit parameters, write configuration data to FPAA (Ctrl + W), set the generator waveform amplitude to V_{we} = 100 mV and measure as a function of frequency according to the table.

Tips! For each measured filter (F6), first search experimentally frequency f_0 (approx. 10 kHz), for which the output voltage reaches the maximum value, $V_{wy,max}$, then calculate 0,707*$V_{wy,max}$, 0,5*$V_{wy,max}$ and 0,316*$V_{wy,max}$; the value of those products enter into the cells located on the right side of the table. In the next step search frequency corresponding to the calculated output voltages. Keep the input voltage at a constant level: V_{we} = 100 mV.

Choose circuit F6 **Set:** G=1 V/V, Q=3, f=10kHz					**Choose circuit F6** **Set:** G=1 V/V, Q=20, f=10kHz				
f_{we}		V_{wy}		K_u	f_{we}		V_{wy}		K_u
[kHz] le		[mV]		[V/V]	[kHz]		[mV]		[V/V]
f_{L10dB}		$0,316\cdot V_{wy,max}$			f_{L10dB}		$0,316\cdot V_{wy,max}$		
f_{L6dB}		$0,5\cdot V_{wy,max}$			f_{L6dB}		$0,5\cdot V_{wy,max}$		
f_{L3dB}		$0,707\cdot V_{wy,max}$			f_{L3dB}		$0,707\cdot V_{wy,max}$		
f_0		$V_{wy,max}$			f_0		$V_{wy,max}$		
f_{H3dB}		$0,707\cdot V_{wy,max}$			f_{H3dB}		$0,707\cdot V_{wy,max}$		
f_{H6dB}		$0,5\cdot V_{wy,max}$			f_{H6dB}		$0,5\cdot V_{wy,max}$		
f_{H10dB}		$0,316\cdot V_{wy,max}$			f_{H10dB}		$0,316\cdot V_{wy,max}$		

Plot the measured frequency characteristics of filters 20log|K_u| as a function of frequency (vertical axis: logarithmic horizontal axis logarithmic) on single graph. Compare measured and theoretical value of f_0 and $Q = f_0 / (f_{H3dB} - f_{L3dB})$

5.2. Design and program the circuit according to Fig. 6 in the manual. Redraw the two waveforms (sine and square-wave), measure THD and discuss results.

THD_{RCX}=………..

THD_{RAX}=………..

<u>Remark!</u>

For each measurement results, include your own conclusions and observations. Compare the circuits with each other. Compare the results of calculations with the measurements. Write your own comments to the results.