Laboratory of analog linear circuits

No exercise in the script: **4A**		Members 1. 2. 3.

Subject: Basic configurations of bipolar transistor

Date of doing exercises *(day of week and time)*		Date of dispatch of the report to the following address:…….: (*valid PDF format).*

2.1. Measurement of the lower and upper cut-off frequencies f_{L3dB} and f_{H3dB} and the input and output resistances R_{in} i R_{out}; for circuit CE set such V_{in} that V_{out} = 800 mV, for circuits CE-RE and CB, V_{out} = 300 mV; and for CC- V_{in} = 300 mV; for circuits A i B: $f_1 = 50\,kHz$, and for circuits C i D: $f_1 = 150\,kHz$

Circuit		A: CE	B: CE-RE	C: CC	D: CB
V_{in}	$[mV]$			**300**	
f_{L3dB}, $K_u(f_{L3dB}) = 0.707 \cdot K_u(f_1)$	$[kHz]$				
V_{out}	$[mV]$	**800**	**300**		**300**
f_{H3dB}, $K_u(f_{H3dB}) = 0.707 \cdot K_u(f_1)$	$[kHz]$				
$f_0 = \sqrt{f_{L3dB} \cdot f_{H3dB}}$	$[kHz]$				
$K_u(f_0)$	$[V/V]$				
Measure R_{in}: V_{out}'	$[mV]$				
Measure R_{out}: V_{out}'	$[mV]$				

2.2. Measure of amplitude characteristics CE, CE-RE, CC and CB, $K_u = V_{out}/V_{in}$, V_{in} as above

A: CE			B: CE-RE			C: CC			D: CB		
f $[kHz]$	K_u $[V/V]$	$20 \cdot \log\lvert K_u \rvert$	f $[kHz]$	K_u $[V/V]$	$20 \cdot \log\lvert K_u \rvert$	f $[kHz]$	K_u $[V/V]$	$20 \cdot \log\lvert K_u \rvert$	f $[kHz]$	K_u $[V/V]$	$20 \cdot \log\lvert K_u \rvert$
200 Hz			100 Hz			70 Hz			10.0		
400 Hz			200 Hz			100 Hz			12.0		
700 Hz			400 Hz			200 Hz			14.0		
1.0			700 Hz			400 Hz			17.0		
2.0			2.0			700 Hz			20.0		
4.0			4.0			1.0			27.0		
7.0			10			10.0			50.0		
10			50			50.0			100.0		
50			100			100.0			500.0		
100			400			150.0			700.0		
150			500			700.0			800.0		
200			600			1 MHz			900.0		
400			700			1.2MHz			1 MHz		
500			1 MHz			1.4MHz			1.2MHz		

3. Production of results

1) Plot the measured characteristics on separate charts. The vertical axis should be gain expressed in logarithmic measure, ie., the horizontal axis (signal frequency) should be logarithmic.

2) Calculate the theoretical operating point of transistors, small signal gain, the input and output.resistances.

For the calculations assume: $V_{CC}=12V$, $V_T=25mV$, $V_{BE}=0.7V$, $\beta=160$, $R_{B_1}=43k\Omega$, $R_{B_2}=22k\Omega$, $R_C=6.2k\Omega$, $R_E=3.13k\Omega$, $R_{E_1}=160\Omega$, $R_{BUF}=1000k\Omega$, $R_S'=1k\Omega$, $R_L'=4.7k\Omega$

Operating point: $V_B=V_{CC}\dfrac{R_{B_2}}{R_{B_1}+R_{B_2}}=.....$, $I_C=\dfrac{V_B-V_{BE}}{R_E}=.....$, $V_{CE}=V_{CC}-\left(R_C+R_E\right)\cdot I_C=.....$

Additionally calculate: $g_m=\dfrac{I_C}{V_T}=.....$, $r_\pi=\dfrac{\beta}{g_m}=.....$, $r_e=\dfrac{r_\pi}{\beta+1}=.....$

By calculations use the following formulas:

A: CE	**B: CE-RE**	**D: CB**
Small signal gain K_u		
$-\dfrac{R_{in}}{R_{in}+R_S}\cdot g_m\cdot\dfrac{R_C\cdot R_{BUF}}{R_C+R_{BUF}}$,	$-\dfrac{R_{in}}{R_{in}+R_S}\cdot\dfrac{r_\pi}{r_\pi+(\beta+1)R_{E_1}}\cdot g_m\cdot\dfrac{R_C\cdot R_{BUF}}{R_C+R_{BUF}}$,	$-\dfrac{R_{in}}{R_{in}+R_S}\cdot\dfrac{\beta}{(\beta+1)\cdot r_e}\cdot\dfrac{R_C\cdot R_{BUF}}{R_C+R_{BUF}}$
Theoretical input resistance R_{in}		
$r_\pi \Vert R_{B_1} \Vert R_{B_2}=\left(\dfrac{1}{r_\pi}+\dfrac{1}{R_{B_1}}+\dfrac{1}{R_{B_2}}\right)^{-1}$	$\left(r_\pi+(\beta+1)R_{E_1}\right)\Vert R_{B_1}\Vert R_{B_2}=\left(\dfrac{1}{r_\pi+(\beta+1)R_{E_1}}+\dfrac{1}{R_{B_1}}+\dfrac{1}{R_{B_2}}\right)^{-1}$	$R_{in}=R_E\Vert r_e=\dfrac{R_E\cdot r_e}{R_E+r_e}$
Measured input resistance R_{in}		
$R_{in}=\dfrac{V_{out}'}{V_{out}-V_{out}'}\cdot R_S'-R_S$		
$R_S=1k\Omega$	$R_S=1k\Omega$	$R_S=0.1k\Omega$
Theoretical output resistance R_{out}		
R_C		
Measured output resistance R_{out}		
$R_{out}=\dfrac{R_{BUF}\cdot R_L'}{\dfrac{R_{BUF}\cdot V_{out}'}{V_{out}-V_{out}'}-R_L'}$		

The calculation results compare with the results of measurements in the table below.

	A: CE		**B: CE-RE**		**C: CC**		**D: CB**	
	theoretical	measured	theoretical	measured	theoretical	measured	theoretical	measured
K_u								
$R_{in}\left[k\Omega\right]$								
$R_{out}\left[k\Omega\right]$								
$f_{L\,3dB}\left[kHz\right]$								
$f_{H\,3dB}\left[kHz\right]$					26 M			

For all measurements in the exercise, place your own conclusions and observations. Compare deals between each other and comment on compliance calculations with the measurements.