LABORATORY OF BASICS OF ELECTRONICS AND METROLOGY			
Exercise: 1A	No. of consecutive exercise:	Team: 1. 2. 3.	
Subject: Examination of the input amplifier stage in operational amplifier		Dean's group:	Laboratory group:
Deadline of exercise:	Execution date of exercise:	Date of delivering of the report:	
Grading:			

2. Measurement of a differential amplifier for differential and common-mode excitations

1) Differential excitation $V_{wyR} = V_{wy1} - V_{wy2}$, switch K1 pressed, tuning by P2

Configuration:	A: R_E, R_C				B: R_E, R'_C				C: R_{E1}, R_C				D: R_{E2}, R_C			
V_{weR}	V_{wy1}	V_{wy2}	I_E	V_{wyR}	V_{wy1}	V_{wy2}	I_E	V_{wyR}	V_{wy1}	V_{wy2}	I_E	V_{wyR}	V_{wy1}	V_{wy2}	I_E	V_{wyR}
[mV]	[V]	[V]	[mA]	[V]	[V]	[V]	[mA]	[V]	[V]	[V]	[mA]	[V]	[V]	[V]	[mA]	[V]
-130																
-120																
-100																
-80																
-60																
-40																
-20																
0																
20																
40																
60																
80																
100																
120																
130																

Make plots:

- $V_{wyR} = f(V_{weR})$, ie. a joint plot of four functions for differential input voltage V_{weR} for four configurations: A, B, C and D.
- $I_E = f(V_{weR})$, ie. a joint plot of I_E as a function of the differential input voltage V_{weR} for four configurations: A, B, C and D.

2) Common-mode excitation $V_{wyS} = V_{wy1} - V_{wy2}$, switch K1 depressed, tuning by P1

Attention: These measurements should be performed very accurate, noting the values up to three decimal place.

Configuration:	A: R_E, R_C				B: R_E, R'_C				C: R_{E1}, R_C				D: R_{E2}, R_C			
V_{weS}	V_{wy1}	V_{wy2}	I_E	V_{wyS}	V_{wy1}	V_{wy2}	I_E	V_{wyS}	V_{wy1}	V_{wy2}	I_E	V_{wyS}	V_{wy1}	V_{wy2}	I_E	V_{wyS}
[V]	[V]	[V]	[mA]	[V]	[V]	[V]	[mA]	[V]	[V]	[V]	[mA]	[V]	[V]	[V]	[mA]	[V]
-5																
-4																
-3																
-2																
-1																
0																
1																
2																
3																
4																
5																

Make plots:

- $V_{wyS} = f(V_{weS})$, ie. a joint plot of four functions for common-mode input voltage V_{weS} for four configurations: A, B, C and D.
- $I_E = f(V_{weS})$, ie. a joint plot of I_E as a function of the common-mode input voltage V_{weS} for four configurations: A, B, C and D.

3) For each configuration A, B, C, D, based on results of measurements it should be calculated differential gain K_r, common-mode gain K_s, and CMRR coefficient. The differential gain K_r should be calculated as a slope of a linear function $V_{wyR} = f(V_{weR})$, whereas the common-mode gain K_s as a slope of a linear function $V_{wyS} = f(V_{weS})$. The CMRR coefficient is to be calculated as a ratio of the differential gain K_r to the common-mode gain K_s and should be expressed in dB, ie. $CMRR = 20log\left|\frac{K_r}{K_s}\right|$.

Configuration:	A: R_E, R_C	B: R_E, R'_C	C: R_{E1}, R_C	D: R_{E2}, R_C
K_r, [V/V]				
K_s, [V/V]				
$CMRR$, [dB]				

4) Using the schematics of the amplifier in configuration A and B, calculate: the operation point of T1 and T2, value of current I_E, and the differential voltage gain K_r. Compare the measurement results with the calculated values for I_E and K_r.

In calculations assume: V_{CC} = 12 V, V_{BE} = 0.7 V, R_C = 12 kΩ, R'_C = 2 kΩ, R_E = 12 kΩ, R_e = 385 Ω.

Operation point for configuration A: $I_E = \frac{V_{CC} - V_{BE}}{R_E + \frac{R_e}{2}}$, $V_C = V_{CC} - \frac{R_C I_E}{2}$,

Operation point for configuration B: $I_E = \frac{V_{CC} - V_{BE}}{R_E + \frac{R_e}{2}}$, $V_C = V_{CC} - \frac{R_{C'} I_E}{2}$

in addition calculate: $g_m = \frac{I_E}{2 \cdot V_T} = ...$, $g_m^* = \frac{g_m}{2(1 + R_e \cdot g_m)} = ...$.

differential voltage gain for config. A: $K_r = -2 R_C g_m^*$, differential voltage gain for config. B: $K_r = -2 R_{C'} g_m^*$.

Attention: compare measured values for $V_{we} = 0$.

Configuration:	A: R_E, R_C		B: R_E, R'_C	
	calculated	measured	calculated	measured
I_E, [mA]				
V_C, [V]				
K_r, [V/V]				

For all measurements give your own conclusions and observations. Compare circuits between each other and comment on the compliance calculations with the measurements.