Session 3 Lab Report: BJTs

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Absolute Maximum Ratings

Stresses exceeding the absolute maximum ratings may damage the device. The device may not function or be operable above the recommended operating conditions and stressing the parts to these levels is not recommended. In addition, extended exposure to stresses above the recommended operating conditions may affect device reliability. The absolute maximum ratings are stress ratings only. Values are at T_A = 25°C unless otherwise noted.

Symbol	Parameter		Value	Unit
V_{CBO}	Collector-Base Voltage	BC546	80	V
		BC547 / BC550	50	
		BC548 / BC549	30	
V_{CEO}	Collector-Emitter Voltage	BC546	65	V
		BC547 / BC550	45	
		BC548 / BC549	30	
V_{EBO}	Emitter-Base Voltage	BC546 / BC547	6	V
		BC548 / BC549 / BC550	5	
I_C	Collector Current (DC)		100	mA
P_C	Collector Power Dissipation		500	mW
T_J	Junction Temperature		150	°C
T_{STG}	Storage Temperature Range		-65 to +150	°C

Electrical Characteristics

Values are at T_A = 25°C unless otherwise noted.

Symbol	Parameter		Conditions	Min.	Typ.	Max.	Unit
I_{CBO}	Collector Cut-Off Current		V_{CB} = 30 V, I_E = 0			15	nA
h_{FE}	DC Current Gain		V_{CE} = 5 V, I_C = 2 mA	110		800	
V_{CE}(sat)	Collector-Emitter Saturation Voltage		I_C = 10 mA, I_B = 0.5 mA		90	250	mV
			I_C = 100 mA, I_B = 5 mA		250	600	
V_{BE}(sat)	Base-Emitter Saturation Voltage		I_C = 10 mA, I_B = 0.5 mA		700		mV
			I_C = 100 mA, I_B = 5 mA		900		
V_{BE}(on)	Base-Emitter On Voltage		V_{CE} = 5 V, I_C = 2 mA	580	660	700	mV
			V_{CE} = 5 V, I_C = 10 mA			720	
f_T	Current Gain Bandwidth Product		V_{CE} = 5 V, I_C = 10 mA, f = 100 MHz		300		MHz
C_{ob}	Output Capacitance		V_{CB} = 10 V, I_E = 0, f = 1 MHz		3.5	6.0	pF
C_{ib}	Input Capacitance		V_{EB} = 0.5 V, I_C = 0, f = 1 MHz		9		pF
NF	Noise Figure	BC546 / BC547 / BC548	V_{CE} = 5 V, I_C = 200 µA, f = 1 kHz, R_G = 2 kΩ		2.0	10.0	dB
		BC549 / BC550			1.2	4.0	
		BC549	V_{CE} = 5 V, I_C = 200 µA, R_G = 2 kΩ, f = 30 to 15000 MHz		1.4	4.0	
		BC550			1.4	3.0	

h_{FE} Classification

Classification	A	B	C
h_{FE}	110 ~ 220	200 ~ 450	420 ~ 800

Preparation 1

① $V_{CEO_{max}} = 65\,V$ $\quad I_{C_{max}} = 100\,mA$

$h_{FE} = 110$ $\quad V_{BE} = 0{,}66\,V$ at $2\,mA$

($V_{CE} = 5V$, $I_C = 2mA$)

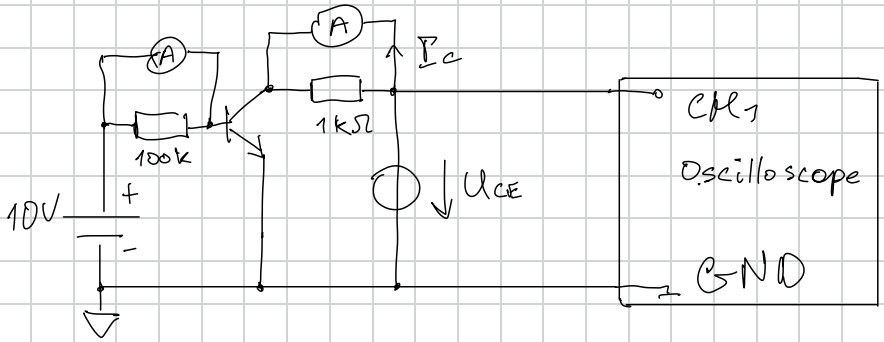
DC current gain

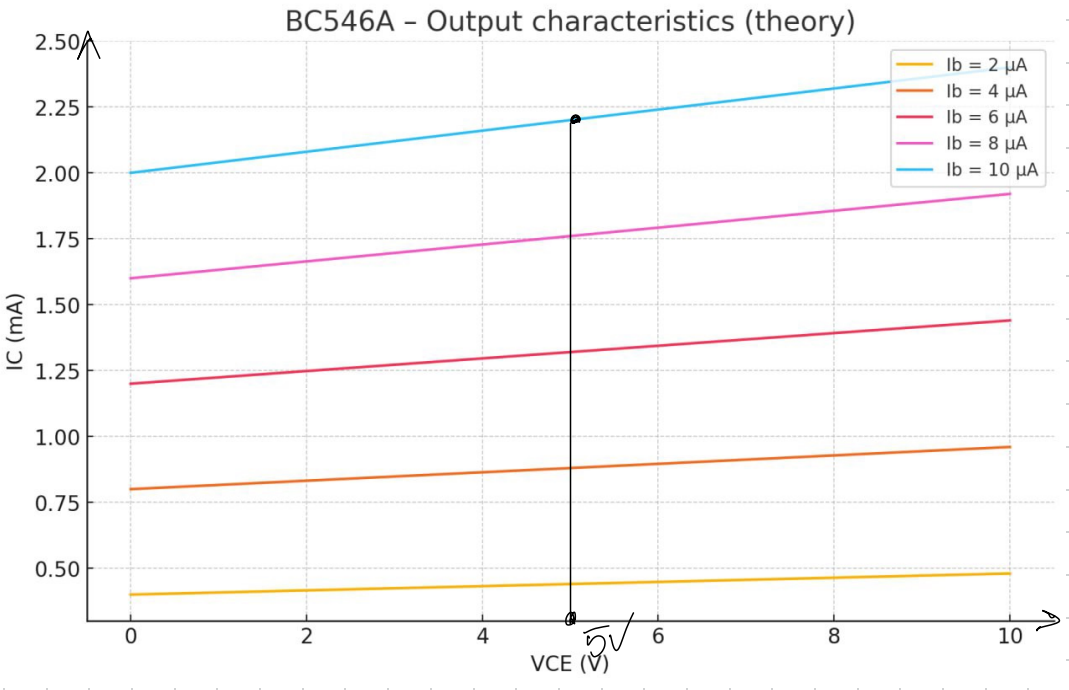
② $I_C = 0 \ldots 2mA$ $\quad h_{FE(min)} = 110$

$I_B = \frac{I_C}{h_{FE(min)}} \Rightarrow$ for $I_C = 2mA$ $\quad I_B = \frac{2mA}{110} = 18{,}18\,\mu A$

$U_{CE} = 0 - 10\,V$

U_{CE}, V	0	6,12	6,09	6,07	6,05	6,04
I_C, mA	0	0,5	1	1,5	1,75	2
Calculated I_B, µA	0	4,54	9,09	13,6	15,9	18,18
Measured I_B, µA	0	3,43	7	10,6	13,8	14,51





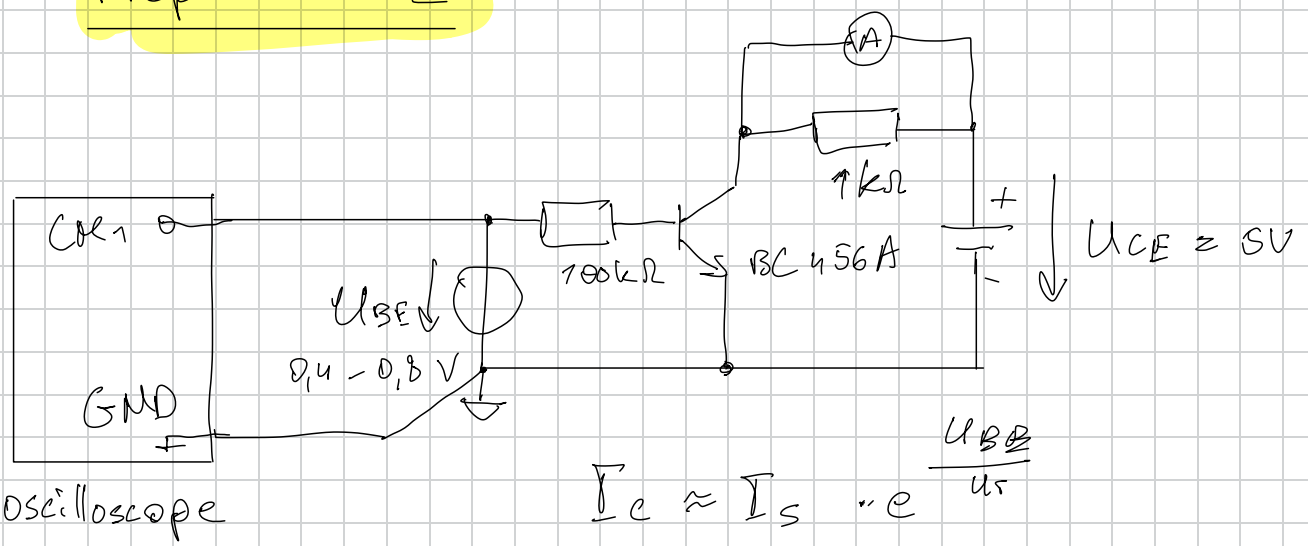
Average current gain

$I_{gain} \approx 2{,}2\,mA$

Early voltage

$V_A \approx 50\,V$

Preparation 2



$$I_C \approx I_S \cdot e^{\frac{U_{BE}}{U_T}}$$

$I_S \approx 1 \cdot 10^{-14}$ A typically

$U_T \approx 25$ mV at room temperature

Approximate values:

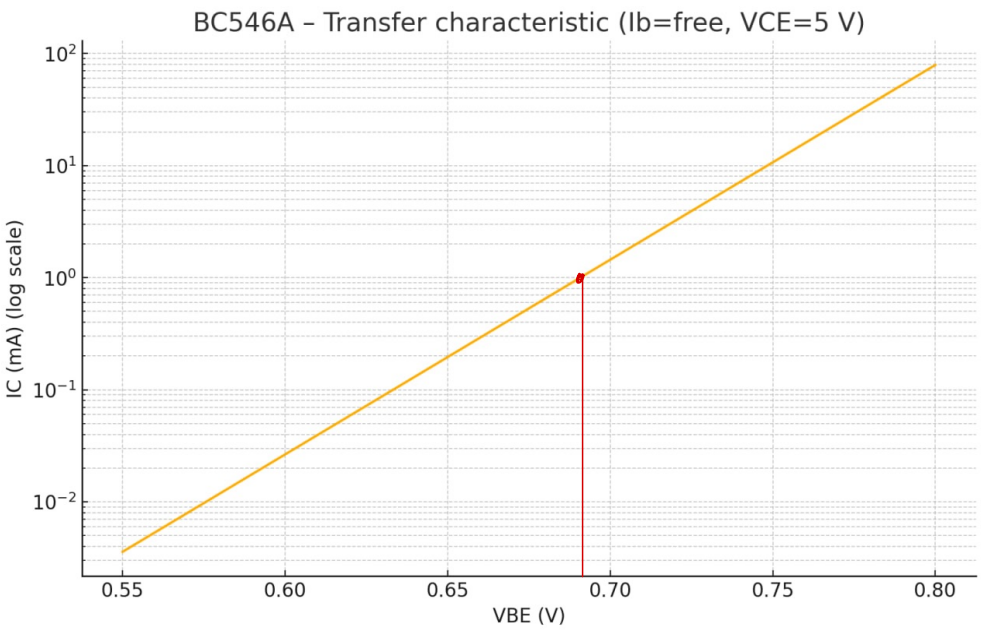
U_{BE}, mV	500	600	650	700	720	740	750
Calculated I_C	1,9 µA	110 nA	820 nA	6,1 µA	1,7 mA	4,6 mA	7,4 mA
Measured I_C	60 µA	147 µA	198 µA	250 µA	270 µA	296 µA	307 µA

Evaluation 2

Transconductance at $I_C = 1$ mA

$$I_S = I_C \cdot e^{-\frac{U_{BE}}{U_T}}$$

$g_m = 40$ mS



$I_S \approx 1 \cdot 10^{-15}$ A

Saturation current

Preparation 3.

Assuming $U_B = 10V$

Let's say $U_{CE} = \frac{1}{2} U_B = 5V$

$$R_C = \frac{U_B - U_{CE}}{I_C} = \frac{10V - 5V}{2mA} = 2{,}5\ k\Omega$$

(collector resistor)

↓

2,7 kΩ (E12)

$U_E \sim 10\%$ of $U_B = 1V$

$$R_E = \frac{U_E}{I_E} = 500\Omega \rightarrow 560\Omega \ (E12)$$

(emitter resistor)

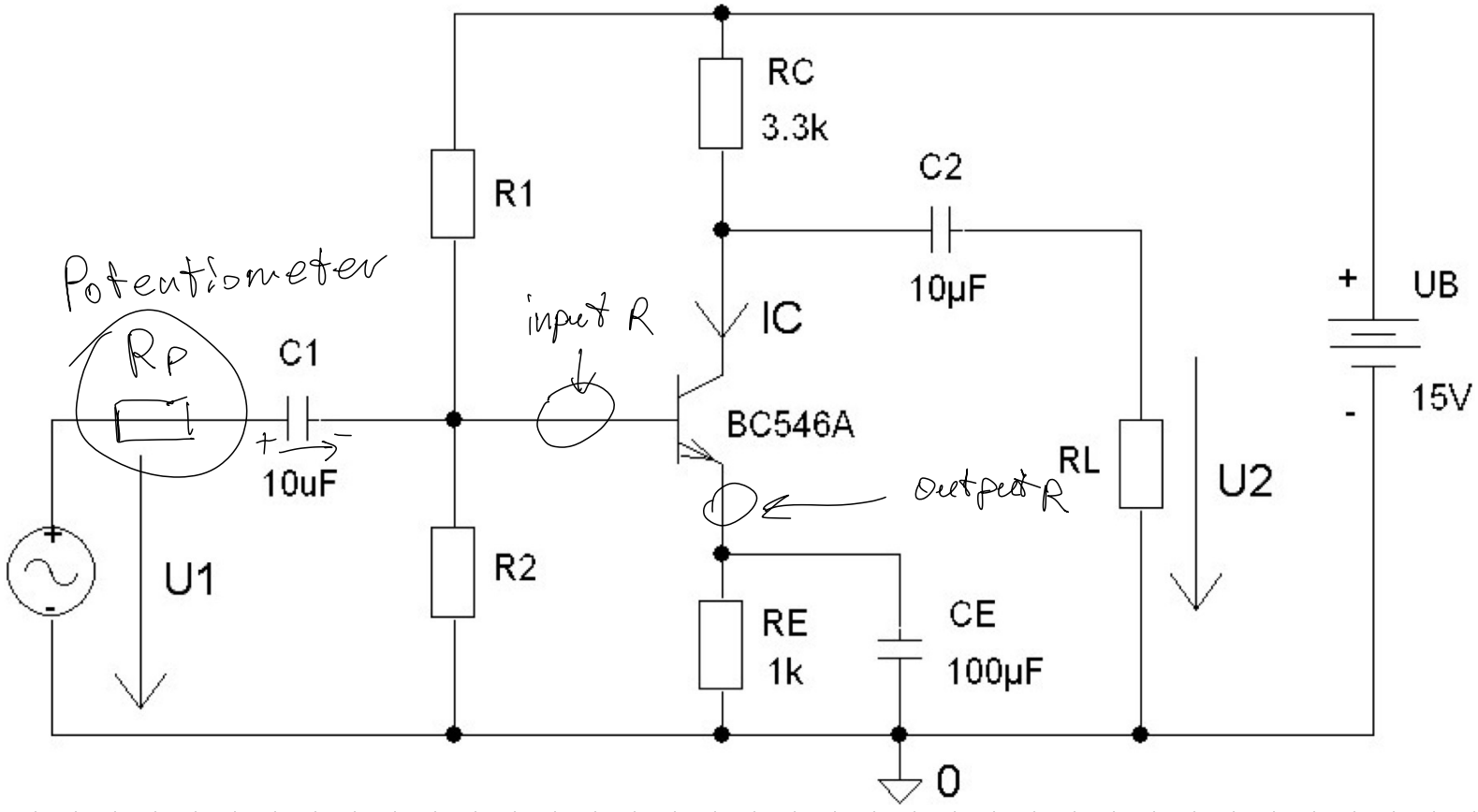
$$V_B = U_E + U_{BE} \approx 1V + 0{,}65V = 1{,}65V$$

Divider Current $\approx 10 \cdot I_B \sim 0{,}18\ mA$

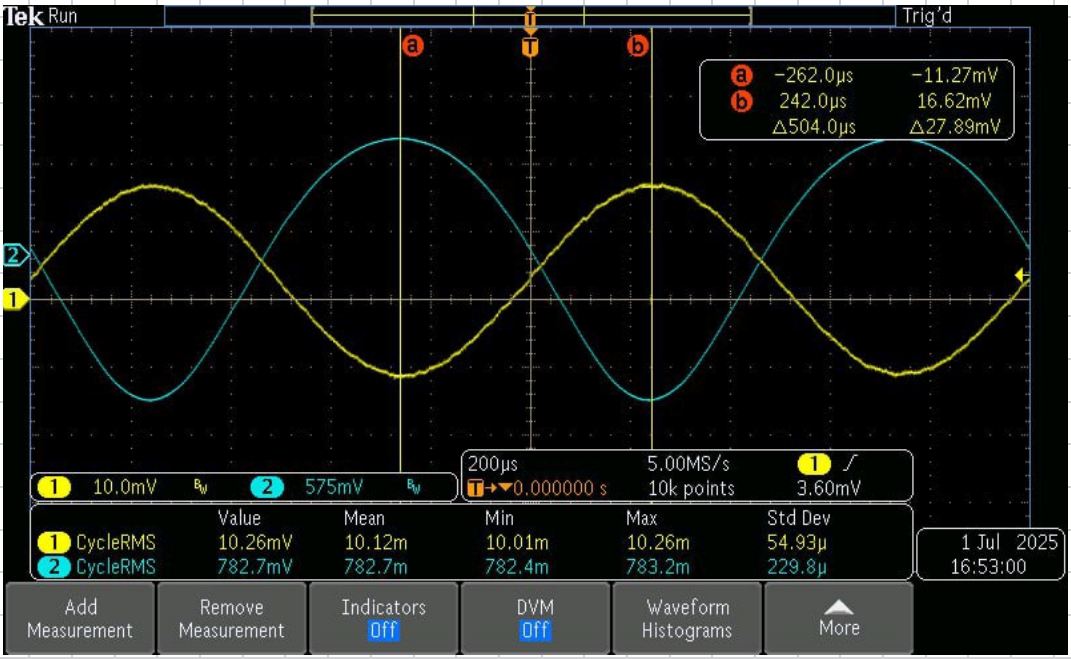
$$R_2 = \frac{V_B}{0{,}18mA} = 9{,}16\ k\Omega \Rightarrow (8{,}2 + 1)\ k\Omega$$

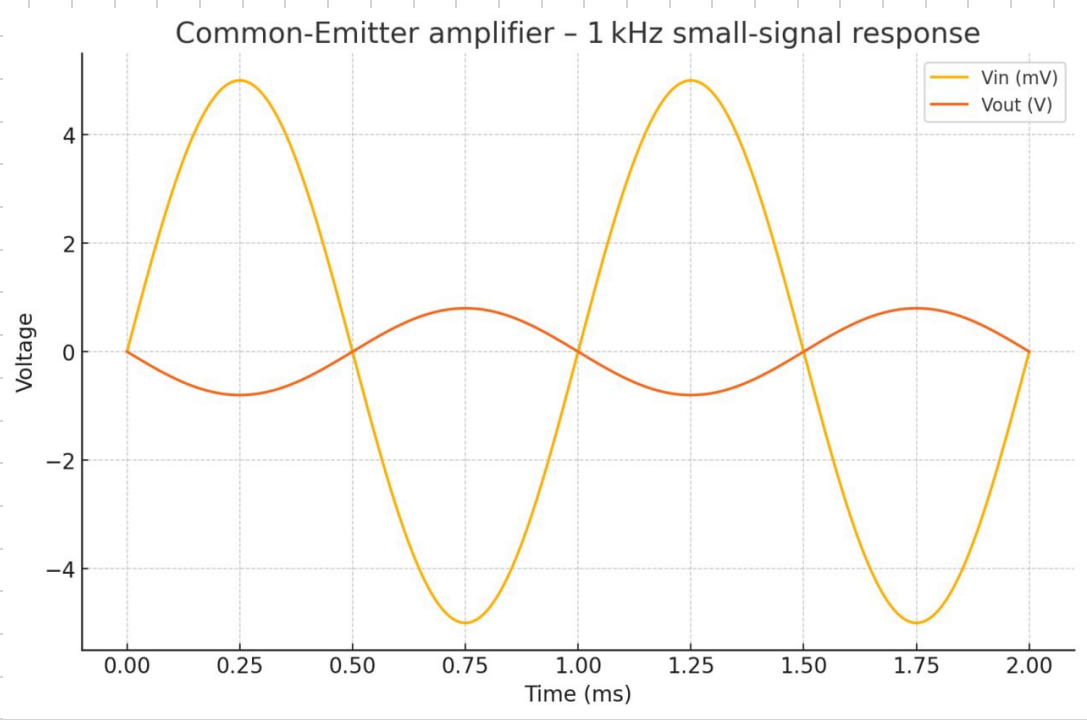
$$R_1 = \frac{U_B - V_B}{0{,}18\ mA} = 46{,}39\ k\Omega \Rightarrow (4{,}7 + 10)\ k\Omega$$

in practice $R_2 \sim 10k\Omega$ and $R_1 \sim 100k\Omega$



Results from the LAB





Measured internal resistance $R_{in} \approx 830\ \Omega$

output resistance $R_{out} \approx 2{,}9\ k\Omega$