EE315 - Electronics Laboratory

Experiment - 3
BJT Transistor and DC Biasing

Preliminary Work

1. For the circuit given in Figure **1**

a) Calculate the value of $\mathbf{R_{adj}}$ that makes $\mathbf{V_{CE}}$ equal to **5 V**.

b) Calculate $\mathbf{V_{RB}}$ (voltage drop accross $\mathbf{R_B}$).

c) Explain the reason for choosing $\mathbf{V_{CE}}$ equal to **5 V**.

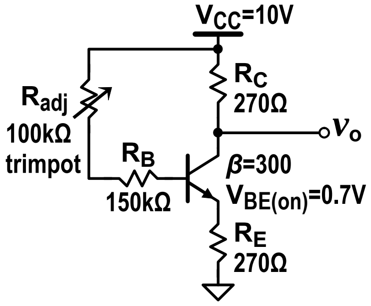


Figure 1. Emitter-stabilized bias circuit

2. For the circuit given in Figure **2**, determine $\mathbf{I_B}$, $\mathbf{I_C}$, $\mathbf{V_B}$, $\mathbf{V_E}$, and $\mathbf{V_{CE}}$.

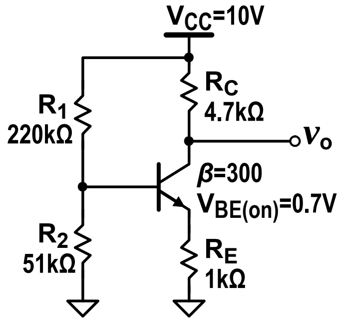


Figure 2. Voltage divider biasing circuit

3. For the circuit given in Figure **3**, derive an expression for $\boldsymbol{v_O = v_C}$ as a function of $\boldsymbol{v_{drv}}$. Specify the $\boldsymbol{v_{drv}}$ levels where the transistor turns off completely ($\boldsymbol{i_C = 0}$) and it goes into saturation ($\boldsymbol{i_C < \beta i_B}$).

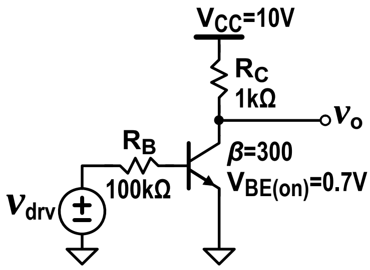


Figure 3. Switching circuit

4. For the circuit given in Figure **4**, find the values of $\mathbf{R_C}$ and $\mathbf{R_B}$, so that $\mathbf{I_{Csat} = 2\ mA}$ and $\boldsymbol{v_O}$ changes between **10 V** and **0 V** while $\boldsymbol{v_{drv}}$ is a **1 kHz** square wave signal switching between **0 V** and **10 V**.

Draw $\boldsymbol{v_{drv}}$ and $\boldsymbol{v_O}$ as a function of time.

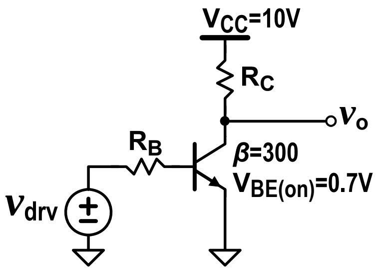


Figure 4. Switching circuit

Procedure

1. Build the circuit given in Figure **1**. Turn on the power supply on and adjust $\mathbf{R_{adj}}$ so that $\mathbf{V_{CE}}$ is **5 V**.

1.a) Measure $\mathbf{V_{BE}}$ and the voltages across $\mathbf{R_B}$, and $\mathbf{R_C}$ while $\mathbf{V_{CE}}$ is still at **5 V**. Measure the resistance values for $\mathbf{R_{adj}}$, $\mathbf{R_B}$, $\mathbf{R_C}$, and $\mathbf{R_E}$. Calculate $\mathbf{I_B}$, $\mathbf{I_C}$, and $\boldsymbol{\beta}$ based on your measurements.

$\mathbf{V_{BE}}$ = $\mathbf{V_{RB}}$ = $\mathbf{V_{RC}}$ =

$\mathbf{R_{adj}}$ = $\mathbf{R_B}$ = $\mathbf{R_C}$ = $\mathbf{R_E}$ =

$\mathbf{I_B}$ = $\mathbf{I_C}$ = $\boldsymbol{\beta}$ =

1.b) Which value(s) among $\mathbf{R_B}$, $\mathbf{R_C}$, $\mathbf{R_E}$, $\boldsymbol{\beta}$, and $\mathbf{V_{BE(on)}}$ is/are the most significant cause of error between the calculated and measured values of $\mathbf{R_{adj}}$?

2.a) Build the circuit in Figure **2**. Measure the values of $\mathbf{I_B}$, $\mathbf{I_C}$, $\mathbf{V_B}$, $\mathbf{V_{BE}}$, and $\mathbf{V_{CE}}$.

2.b) Replace the transistor with another transistor with the same part number (i.e. replace BC238 with another BC238) and repeat the measurements.

Measurement	1st Transistor	2nd Transistor
$\mathbf{I_C}$		
$\mathbf{I_B}$		
$\mathbf{V_B}$		
$\mathbf{V_{BE}}$		
$\mathbf{V_{CE}}$		

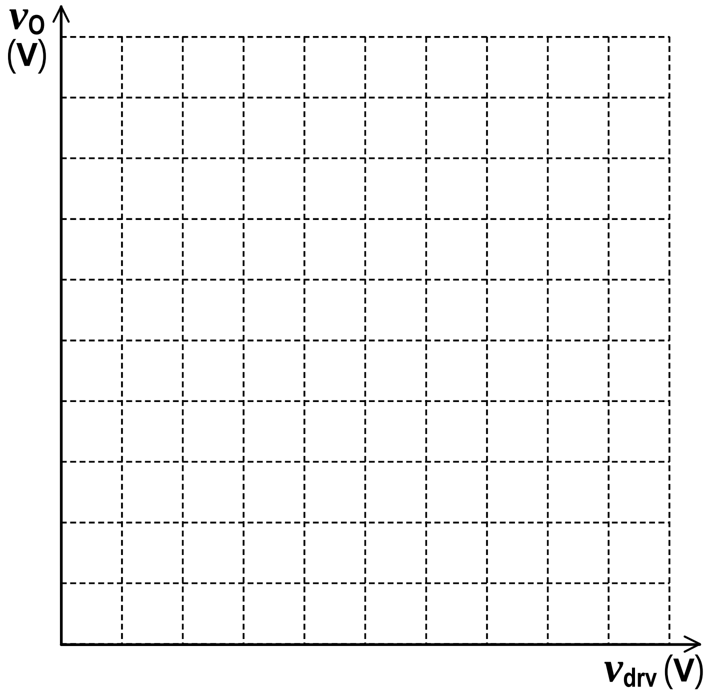
2.c) In practice, all component values are specified with a tolerance range. Tolerance range determines the minimum and maximum of the actual values that will be obtained if several of these components are tested. For example, a **100 kΩ** resistor with **5 %** tolerance may have an actual value between **95 kΩ** and **105 kΩ** . Similarly, the minimum and maximum values of $\boldsymbol{\beta}$ are given in transistor datasheets.

If thousands of this circuit are to be manufactured, then you had to make sure that $\mathbf{V_{CE}}$ will be reasonable within the tolerance range of all components. Indicate in the table below, which end ("**min**" or "**max**") of the tolerance range should be used for each parameter in calculation of the lowest and highest values of $\mathbf{V_{CE}}$.

Component parameter	For lowest $\mathbf{V_{CE}}$	For highest $\mathbf{V_{CE}}$
$\mathbf{R_1}$		
$\mathbf{R_2}$		
$\mathbf{R_C}$		
$\mathbf{R_E}$		
$\boldsymbol{\beta}$		
$\mathbf{V_{BE(on)}}$		

3.a) Build the circuit given in Figure **3**. Increase v_{drv} slowly, from **0V** up to the value where v_O becomes constant. Record at least 10 values in order to plot a v_O versus v_{drv} graph.

v_{drv} (V)	v_O (V)



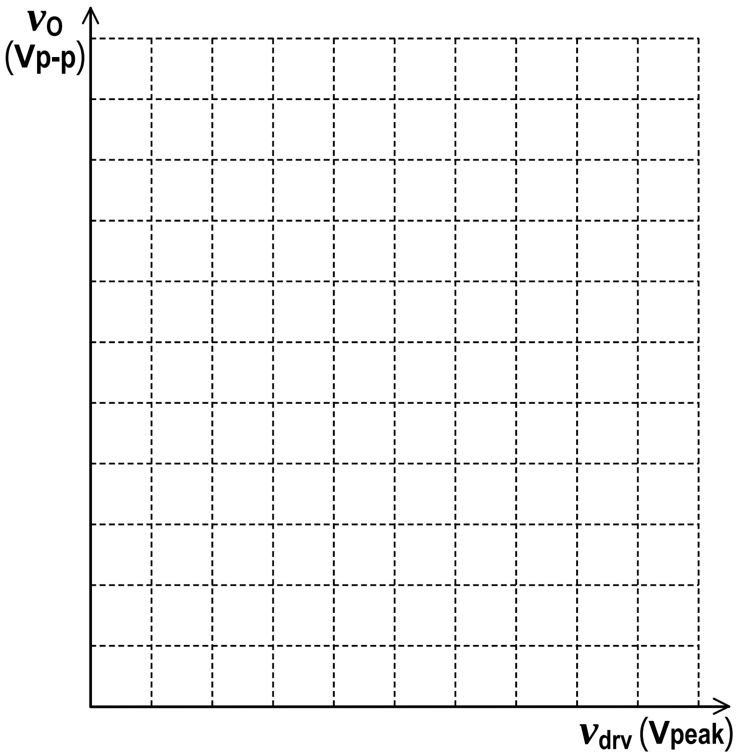
3.b) Measure the range of v_{drv} values in which the transistor acts as a switch.

$v_{drv\text{-}Low\text{-}Max}$ = (where v_O **> 90% of** V_{CC})

$v_{drv\text{-}High\text{-}Min}$ = (where v_O **< 10% of** V_{CC})

4.a) Setup the circuit in Figure **4** using the $\mathbf{R_B}$ and $\mathbf{R_C}$ values previously calculated in the preliminary work. Observe and plot $\mathbf{V_O}$ (Vp-p) versus $\mathbf{V_{drv}}$ (Vpeak) for different frequency and amplitude settings of input signal. Choose a range of $\mathbf{V_{drv}}$ values to cover the minimum and maximum possible $\mathbf{V_O}$ amplitudes at **10 kHz** in your measurements. Use two more frequency settings where the $\mathbf{V_O}$ amplitude decreases by **20 %** and **50 %** at the maximum $\mathbf{V_{drv}}$ value used at **10 kHz**.

Freq. (kHz)	v_{drv} (Vpeak)	v_O (Vp-p)
10		



4.b) Comment on the difference in the output signals resulting from the changes in input parameters.