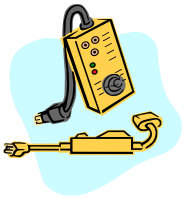
BJT OPERATING REGIONS

I. OBJECTIVES

a) Experimental determination of the boundaries between the operating regions of the BJT.
b) Understanding how a BJT can be used as a switch, for logic circuits, or as an amplifier.



II. COMPONENTS AND INSTRUMENTATION

Use the breadboard, an 2N2368 npn BJT, some resistors and two LEDs. The supply is obtained from the double dc regulated voltage supply. The input voltage is obtained from the signal generator. To visualize the voltage waveforms, a dual-channel oscilloscope is used.

The terminals of the 2N2368 npn BJT are shown in Fig. 1.

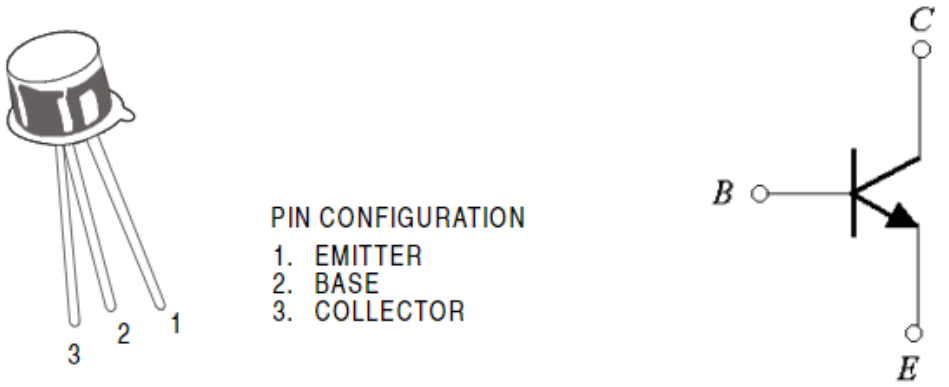


Fig. 1. Pinout diagram for 2N2368 npn BJT

III. PREPARATION

For T we consider: β=100, V_{BEon} = 0.6 V, V_{CEsat} = 0.2 V.

1.P. THE VTC DEPENDENCE ON R_C AND V_{CC}

For this paragraph, use the circuit from Fig. 2.

- $v_A(t)=10\sin(2\pi\ 1000t)$ [V] [Hz]
- What does the VTC $v_Y(v_A)$look like for the circuit from Fig. 2 with R_B =10 kΩ and R_C = 10kΩ? Specify the operating regions of T (off, a_F, exc) on the plot.
- What are the values of v_A for which T is off? What about the saturation state?
- What does the VTC look like if R_C = 2.2 kΩ? (R_B = 10 kΩ)
- What changes on the VTC when V_{CC} = 15 V?

2.P. BJT AS A SWITCH – THE LOGIC FUNCTION

For this paragraph, use the circuit from Fig. 2 and the logic convention 0 V - "0" logic, 10 V - "1" logic.

- Compute v_Y for $v_A = 0$ V. What is the operating region of T?
- Compute v_Y for $v_A = 10$ V. What is the operating region of T?
- Draw the electric operating table, using v_A as input and v_y as output.
- Draw the logic table, using A as input and Y as output. What is the logic function of the circuit?

3.P. BJT AS AN AMPLIFIER

For this paragraph, use the circuit from Fig. 3 and assume v_A – variable dc voltage, between 0 and 5 V.

- What is the minimum value of v_A for which the LEDs become on? What does this mean, in terms of currents through T?

IV. EXPLORATIONS AND RESULTS

1. THE VTC DEPENDENCE ON R_C AND V_{CC}

Build the circuit in Fig. 2.

Exploration

- $v_A = 10 \sin(2\pi 1000t)$[V][Hz]
- Using the oscilloscope in X-Y mode, visualise $v_Y(v_A)$ for

a) $R_B = 10$ kΩ
$R_C = 10$ kΩ

b) $R_B = 10$ kΩ
$R_C = 2.2$ kΩ

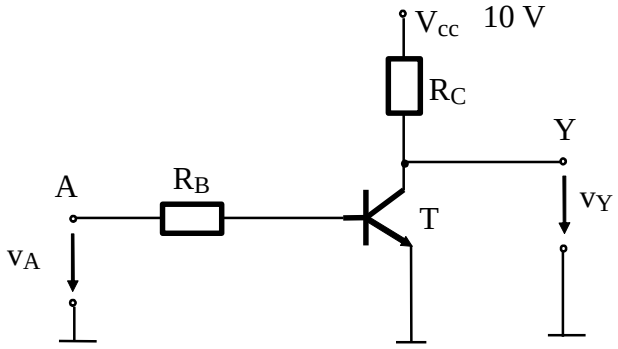


Fig. 2. Circuit with BJT

- Determine the boundaries between off and a_F, and a_F and exc. How are these values modified when R_C changes?
- Change $V_{CC} = 15$ V. Repeat the previous visualizations. Determine the boundaries between off and a_F, and a_F and exc. How are these values modified, compared to the previous case?

Results

- Draw the VTC $v_Y(v_A)$ for the above cases.
- What are the values of v_A for which the BJT is off and in exc?

- How do R_C and V_{CC} influence the VTC $v_Y(v_A)$?

2. BJT AS A SWITCH – THE LOGIC FUNCTION

Build the circuit in Fig. 2.

Exploration

- $v_A \in \{0\ V; 10\ V\}$
- Measure v_Y with the dc voltmeter
- Compute the current through T, for $v_A = 0$ V and for $v_A = 10$ V.

Results

- Fill in the following table, using the measured values of v_Y

Input voltage v_A	Output voltage v_Y	Current through T
0 V		
10 V		

- Draw the logic table, using A as input and Y as output. What is the logic function of the circuit?

3. BJT AS AN AMPLIFIER

Build the circuit in Fig. 3.

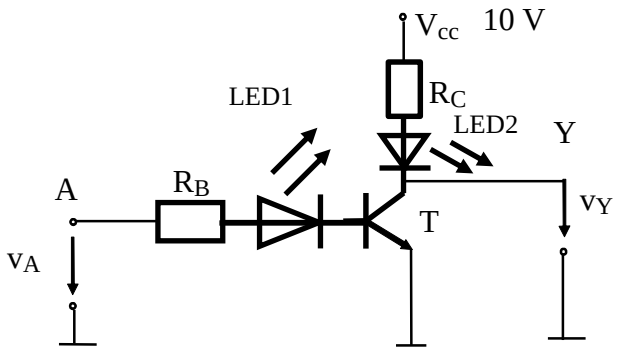


Fig. 3. Circuit with BJT and LEDs

Exploration

- $v_A \in [0\ V; 5\ V]$ – adjustable dc voltage
- Find the minimum value of v_A for which the LEDs become on. How can you tell that the output current (the current in the collector terminal of T) is greater than the input current (the current in the base terminal of T)?

Results

- Minimum value of v_A for which the LEDs become on.

REFERENCES

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