



The Islamic University of Gaza

Faculty of Engineering

Department of Computer Engineering

Electronics I LAB

[LAB 06 & 07]

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Objectives of Ex06:

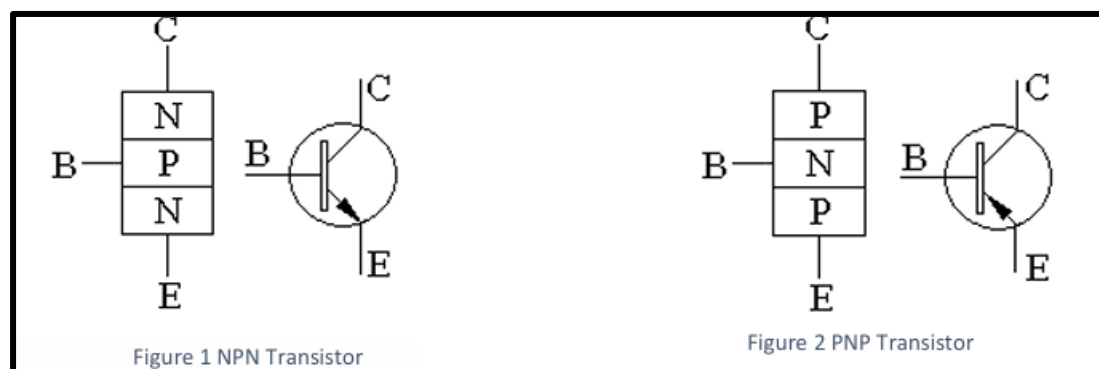
- To study the input and output characteristics of an NPN transistor in Common Emitter mode and determine transistor parameters.
- To plot the Characteristics of a BJT in Common Emitter Configuration.

Equipment of Ex06:

- Resistors.
- DC Power Supply.
- Multi-Meter.

Theory of Ex06:

A Bipolar Junction Transistor (BJT) is a fundamental semiconductor device that functions as a current-controlled amplifier or switch. Its operation is termed "bipolar" because electrical conduction relies on the movement of both charge carriers: electrons and holes. Structurally, it is composed of three distinct semiconductor regions—Emitter, Base, and Collector—which form two p-n junctions. These regions are arranged in one of two primary configurations. In an NPN transistor, a lightly doped P-type base region is situated between two N-type regions; the emitter is heavily doped to efficiently inject electrons, while the collector is moderately doped to gather them. Conversely, a PNP transistor features a lightly doped N-type base sandwiched between heavily doped P-type emitter and collector. The key to its amplification capability lies in the physical design: the base is made extremely thin and lightly doped so that the vast majority of charge carriers injected from the emitter can diffuse across it to be collected by the collector, with only a small fraction recombining to form the base control current.



The three BJT configurations—Common Base (CB), Common Emitter (CE), and Common Collector (CC)—are defined by their current gains: α (I_C/I_E), β (I_C/I_B), and γ (I_E/I_B), respectively. These gains are interdependent and derived from the core current relationship $I_E = I_C + I_B$. The key formulas linking them are:

- $\beta = \alpha / (1 - \alpha)$
- $\alpha = \beta / (1 + \beta)$
- $\gamma = \beta + 1 = 1 / (1 - \alpha)$

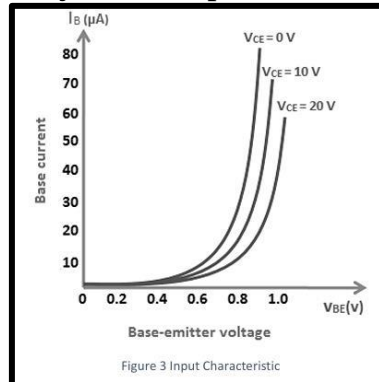
Thus, knowing either α or β allows calculation of all gains, unifying the analysis of BJT behavior across all configurations.

The Common Emitter (CE) configuration is the most widely used transistor amplifier circuit. In this setup, the base serves as the input terminal, the collector as the output terminal, and the emitter is common to both, giving the configuration its name. Its operation is defined by the key relationship that the output collector current I_C is controlled by and is proportional to the input base current I_B , expressed as $I_C = \beta * I_B$, where β is the transistor's DC current gain.

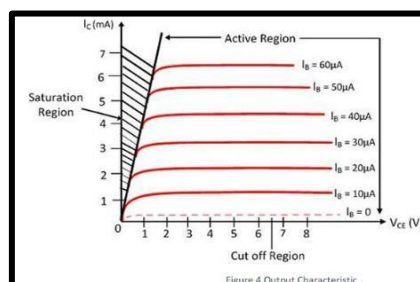
When analyzing its performance, the input characteristics are plotted by examining how the input voltage V_{BE} varies with the input current I_B , while keeping the output voltage V_{CE} constant. Conversely, the output characteristics are plotted by observing how the output current I_C changes with the output voltage V_{CE} , for a fixed base current I_B . This makes the CE configuration a versatile and powerful amplifier due to its high gain in both current and voltage.

Transistor characteristics are of two types:

1) The input characteristics of a Common Emitter (CE) configuration describe the relationship between the input base current (I_B) and the input base-emitter voltage (V_{BE}), while keeping the output collector-emitter voltage (V_{CE}) constant. The resulting curve is similar to a diode's forward bias characteristic. A key point is that for a fixed V_{BE} , the base current I_B decreases slightly as V_{CE} increases. This occurs due to the Early Effect, which involves base-width modulation. The slope of this curve helps determine the dynamic input resistance (r_i) of the transistor.



2) The output characteristics of a Common Emitter (CE) configuration show how the output collector current (I_C) changes with the output collector-emitter voltage (V_{CE}) for a fixed base current (I_B). The graph reveals three main operating regions: the active region where I_C is controlled by I_B and is nearly independent of V_{CE} , the saturation region where I_C rises sharply with V_{CE} , and the cut-off region where I_C is nearly zero. The slope of the curve in the active region indicates the transistor's output resistance.



The different regions of operation of the BJT are:

RB: Reverse Bias.

FB: Forward Bias.

<i>Emitter Junction</i>	<i>Collector Junction</i>	<i>Region</i>	<i>Application</i>
RB	RB	CUTT OFF	OFF SWITCH
FB	FB	SATURATION	ON SWITCH
FB	RB	ACTIVE	AMPLIFIER
RB	FB	REVERSE ACTIVE	ATTENUATOR

Objectives of Ex07:

- To construct a common emitter amplifier circuit and make DC and AC analyze of the system.
- To find all parameters of equivalent model.
- To be familiar how can be simulate common emitter amplifier circuit using LTspice simulation.

Equipment of Ex07:

- Transistor (2N2222A).
- Resistors.
- Capacitors.
- Power Supply.
- Multi-meter.
- Function generator.
- Oscilloscope.

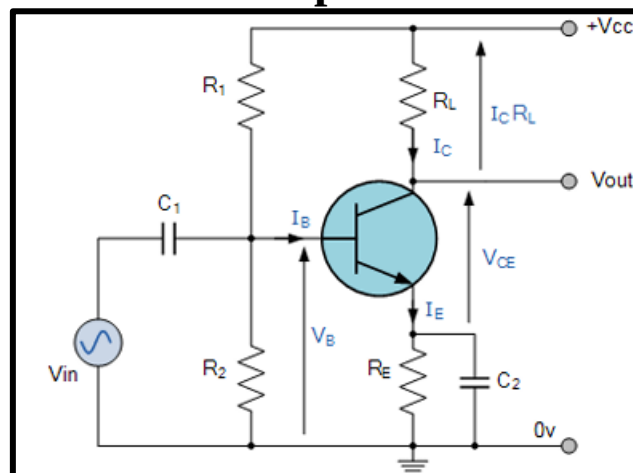
Theory of Ex07:

A common emitter amplifier circuit is designed to amplify a weak input signal without altering its shape, providing both voltage and current gain. A key feature of this configuration is that it introduces a 180-degree phase shift between the input and output signals.

The amplification performance is measured by its gain, which is the ratio of the output signal to the input signal. To ensure the output is a faithful, magnified replica of the input with minimal distortion, the amplifier must be properly biased. This is achieved by setting the DC operating point, or quiescent point (Q-point), correctly.

The optimal location for the Q-point is at the center of the load line (where $V_{ce} = 0.5 * V_{cc}$). This central bias establishes Class A amplifier operation, ensuring the transistor remains in its active region throughout the entire cycle of the input signal, which is crucial for achieving low distortion amplification.

The Common Emitter Amplifier Circuit:



The common emitter amplifier circuit utilizes a biasing method known as voltage divider biasing. This configuration employs two resistors connected in series across the power supply, forming a potential divider network. The key purpose of this network is to provide a stable and precise base bias voltage to the transistor from the midpoint between the two resistors.

This method is a prevalent and fundamental technique in the design of bipolar transistor amplifier circuits due to its ability to establish a stable DC operating point (Q-point), which is crucial for minimizing signal distortion during amplification.

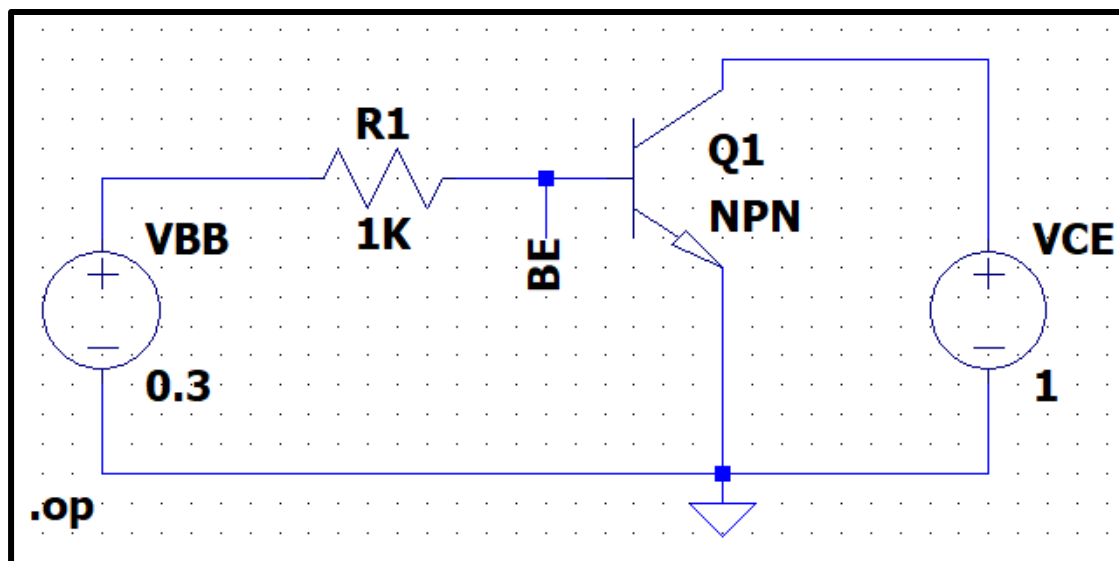
Amplifier Coupling Capacitors:

In a Common Emitter Amplifier, capacitors serve critical functions to separate AC and DC signals and to maximize gain.

- **Coupling Capacitors (C_1 and C_2):** These are placed at the input and output. They block the DC bias voltage from entering the signal source or the next stage, while allowing the AC signal to pass through unimpeded. This isolates the DC operating point of each amplifier stage.
- **Bypass Capacitor (C_E):** This capacitor is connected in parallel with the emitter resistor (R_E). For DC bias conditions, it acts as an open circuit, ensuring the emitter resistor is active to provide crucial Q-point stability and prevent thermal runaway. For the AC signal, it acts as a short circuit, effectively removing the emitter resistor from the

AC circuit. This drastically reduces the circuit's impedance for the AC signal, which maximizes the voltage gain of the amplifier, making it nearly equal to the ratio of the collector resistor (R_C) to the transistor's small internal emitter resistance.

Experiment Procedure of Ex06:



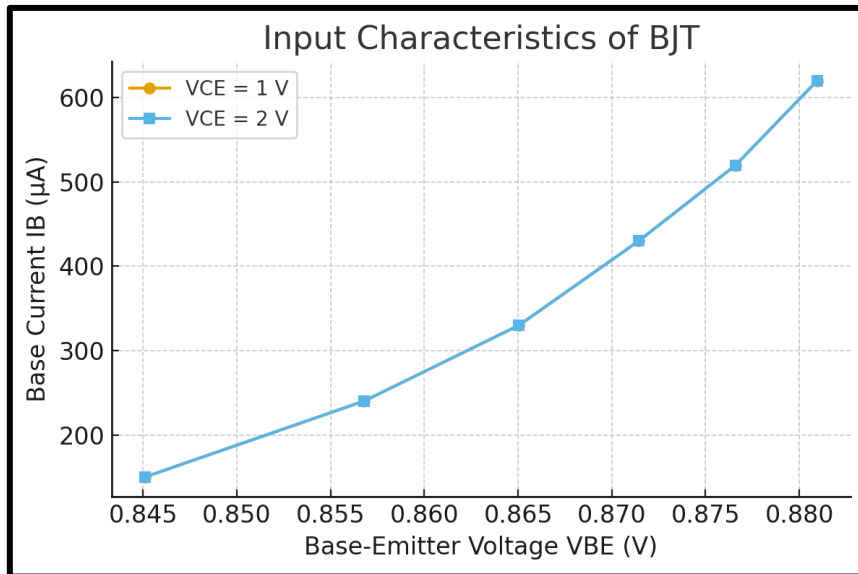
Adjust V_{CE} to 1, 2V and repeat step-3 for each value of V_{CE}

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* C:\Users\NITRO 5\Documents\LTspice\Draft6.asc
--- Operating Point ---
V(n002):      0.3      voltage
V(be):        0.3      voltage
V(n001):      1        voltage
Ic(Q1):       1.15958e-11 device_current
Ib(Q1):       -2.91144e-13 device_current
Ie(Q1):       -1.13046e-11 device_current
I(R1):        2.91144e-13 device_current
I(Vbb):       2.91144e-13 device_current
I(Vce):       -1.15958e-11 device_current
    
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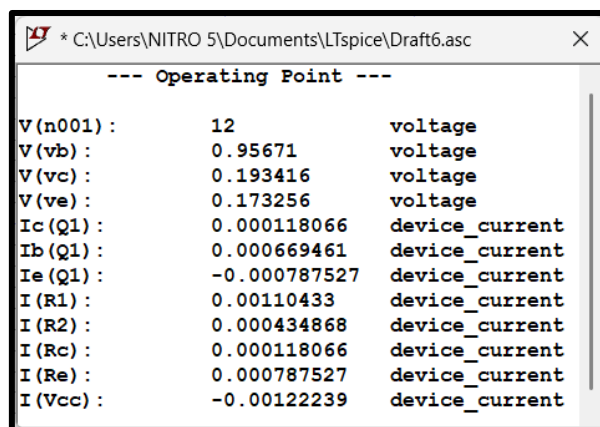
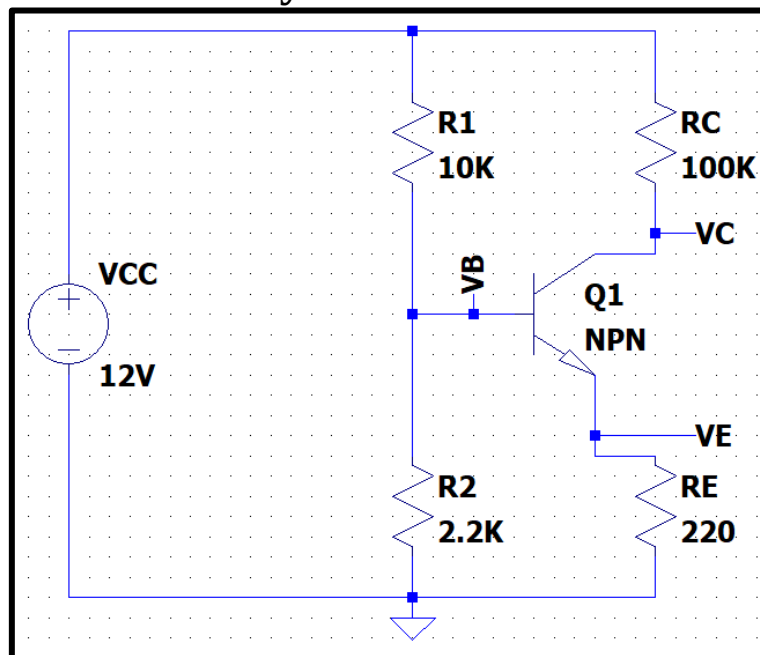
V_{BB}	$V_{CE} = 1$		$V_{CE} = 2$	
	V_{BE}	I_B	V_{BE}	I_B
0	1.0001e-009	-1.0001e-012	2.0001e-009	-2.0001e-012
0.1	0.1	-8.00053e-013	0.1	-1.80005e-012
0.2	0.2	-5.9782e-013	0.2	-1.59782e-012
0.3	0.3	-2.91144e-013	0.3	-1.29114e-012
0.4	0.4	5.00392e-012	0.4	4.00392e-012
0.5	0.5	2.48553e-010	0.5	2.47553e-010
0.6	0.599988	1.18663e-008	0.599988	1.18653e-008
0.7	0.699445	5.54977e-007	0.699445	5.54976e-007
0.8	0.784896	1.51035e-005	0.784896	1.51035e-005
0.9	0.826	7.40004e-005	0.826	7.40004e-005
1	0.845105	0.000154895	0.845105	0.000154895
1.1	0.856777	0.000243223	0.856777	0.000243223
1.2	0.865053	0.000334947	0.865053	0.000334947
1.3	0.871429	0.000428573	0.871429	0.000428573
1.4	0.876599	0.000523401	0.876599	0.000523401
1.5	0.88094	0.000619061	0.88094	0.000619061

Plot a graph between V_{BE} and I_B for different values of V_{CE} . These curves are called input characteristic.



Experiment Procedure of Ex07:

Part01: DC Analysis



I. Set $V_{cc}=12V$, $R_1=10\text{ k}\Omega$, $R_2=2.2\text{ k}\Omega$, $R_c=1\text{ k}\Omega$, and $R_E=220\text{ }\Omega$.

II. Measure the voltages and currents in the circuits

III. Simulate the circuit using LTspice program.

IV. Repeat the previous step when

$R(K\Omega)$	$V_B(V)$	$V_C(V)$	$V_E(V)$	$V_{CE}(V)$	$I_B(\mu A)$	$I_C(mA)$	$I_E(mA)$
1	2.062	6.400	1.244	5.156	0.559	5.559	5.655
4.7	1.424	0.675	0.620	0.0549	410.1	2.409	2.819
100	0.956	0.193	0.173	0.02015	0.669	0.118	0.787

Part02: AC Analysis

