

Transistor Amplifier

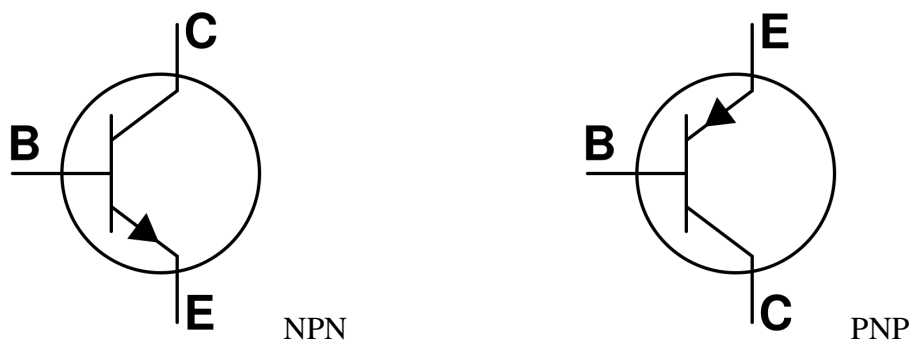
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Theory:

Transistor is a semiconductor device with fast response and accuracy. There are two types of transistors, a Bipolar Junction Transistor and a Field Effect Transistor. Here, we will be looking at a Bipolar Junction Transistor, which is also divided into two categories, PNP and NPN bipolar transistor, which are denoted as the majority charges it carries.

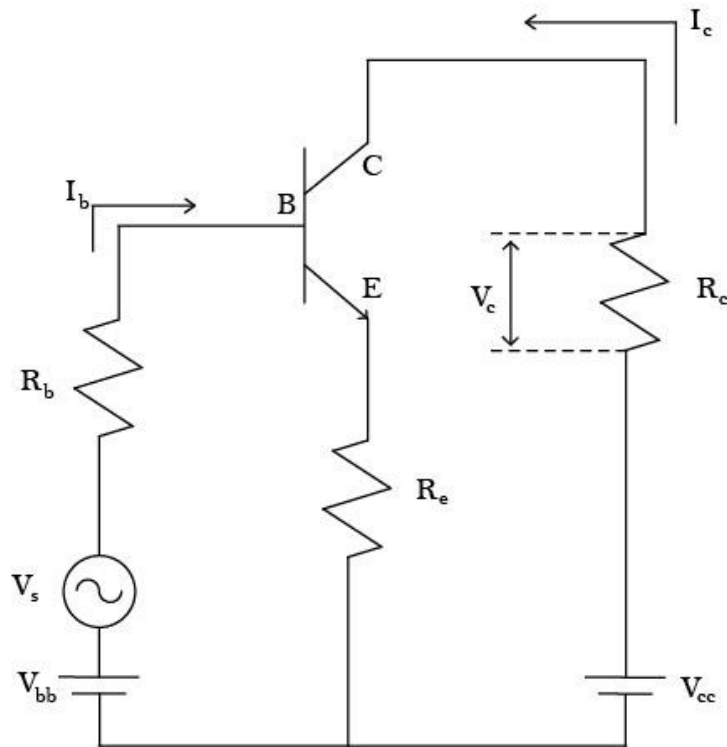


They are also known as the P-type and the N-type respectively. In which, transistor operates on the migration of holes (the positive charge) and electrons (the negative charge). The P-type transistor has the density of electrons in the conduction band exceeded by the density of the holes in the valence band; whereas, for an N-type, the density of the holes in the valence band exceeded the density of the electrons in the conduction band.



Bipolar Junction Transistor is a three terminals device with the Base, Emitter, and Collector electrode. Anyways, because of its fast respond and accuracy, transistor has been used in many applications such as amplifying or switching device.

A transistor amplifier is a current control device. In a transistor amplifier, the current in the base of the transistor controls the current of the collector. Once the current is controlled, it can be used to fine voltage or power gain.



The diagram is a transistor amplifier circuit. The voltages V_{be} and V_{cc} are fixed. To calculate the amplified signal V_s assuming there is a current gain, β , which means there current is $I_c = \beta I_b$, first is to apply the Kirchoff's loop rule to the left hand loop, which will give:

$$I_b = \frac{V_s + V_{bb}}{R_b + (1 + \beta)R_e}$$

Because there is a current gain, β , ($I_c = \beta I_b$) so,

$$I_c = \beta I_b = \beta \frac{V_s + V_{bb}}{R_b + (1 + \beta)R_e}$$

Using I_c from above, the output voltage V_c can be calculated from $V=IR$

$$V_c = I_c R_c = \beta \frac{V_s + V_{bb}}{R_b + (1 + \beta)R_e} R_c$$

From here, the voltage gain, V_s , can be calculated

$$A_v = \frac{V_c}{V_s} = \beta \frac{1 + V_{bb}/V_s}{R_b + (1 + \beta)R_e} R_c$$

Since the voltages V_{cc} and V_{bb} are present only to establish the proper bias on the transistor, it is possible in practice to make $V_{bb} \ll V_{cc}$, (also because we are physicist, not mathematician) so that

$$A_v \approx \beta \frac{R_c}{R_b + (1 + \beta)R_e}$$

Therefore, different transistors can give different voltage gain with individual preference.

Purpose:

This program is made to help looking at different characteristics of a transistor amplifier circuit, and what could affect the amplifying in the circuit. The programs will run through

each of the properties; I_b , I_c , R_b , R_c , R_e , V_c , V_s , V_{bb} , and V_{cc} , to investigate how each individual property has affect on the voltage gain, A_v . The program will have a list of different values for each of the properties for observing the changes in voltage gain while keeping other value constant. On the other hand, it will also calculate a single value for each individual property as well as a single value of a voltage gain with affect from each individual property. None the less, this program will allow the user to read from a file with list of currents that will help giving a better understanding on how the voltage gain be affected by the currents. This program will also show what values needed for each individual property for a specific voltage gain. Indeed it will help to have a better look and give a better understanding on how each of the properties can affect the voltage gain of the circuit.

Instructions:

The program consists of 13 different options, and each Option is a subroutine. Indeed, each of them will show the relationships between different properties, and allow a better understanding of each property in the circuit.

Option A: It will read in a list of input and output currents from a file with any number of data and then calculate the current gain (beta) and voltage gain with some given values of resistor. The it will graph the relationship of current and voltage gain. The file should be named “currents.txt” for this process to work successfully.

Option B: It will show the relationship between the output current and voltage gain, for which in this option, it will calculate the output current with a list of voltage gain from 1 to 100 with the increment of 5.

Option C: Similar as Option B, but it will only calculate the output current with a specific voltage gain.

Option D: It will show the relationship between the source voltage and the voltage gain. To do so, it will calculate the voltage gain with a list of source voltage from 1 to 100 with the increment of 5.

Option E: Similar to Option D, but it will only calculate the voltage gain with a source voltage.

Option F: It will show the relationship between the current gain and the voltage gain. In which, it will calculate the voltage gain with a list of current gain from 1 to 100 with the increment of 5.

Option G: Similar as Option F, but it will only calculate the voltage gain with a specific current gain.

Option H: It will show the relationship between the collector resistor and voltage gain as well as the current gain by calculating the collector resistor with a list of voltage gain and current gain from 10 to 100 with the increment of 10.

Option I: Similar as Option H, it will calculate the collector resistor with specific voltage gain and current gain.

Option J: It will show the relationship between the base resistor and voltage gain as well as the current gain with a list of voltage gain and current gain from 10 to 100 with the increment of 10.

Option K: Similar as Option J, but it will calculate the base resistor with specific voltage and current gain.

Option L: It will show the relationship between the emitter resistor and voltage gain as well as the current with a list of voltage and current gain from 10 to 100 with the increment of 10.

Option M: Similar as Option L, but it will calculate the emitter resistor with specific voltage and current gain.

References:

1. Anonymous "**Transistor Amplifiers**," , (1998).
2. Eric Seale, "Bipolar Junction Transistor (BJT)," , (2003).
3. Thornton, Stephen T., Rex, Andrew, Transistor, in Modern Physics, edited by Anonymous Third Edition ed. (Thomson, 2006), pp. 407.