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Zavádění cizojazyčné terminologie do výuky odborných předmětů a do laboratorních cvičení

Bipolar Transistors

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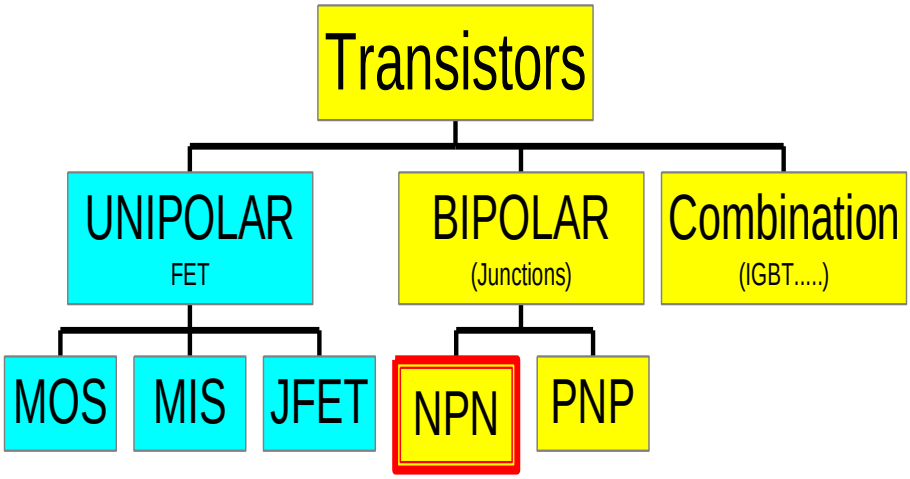
Bipolar Transistors

This tema is well known for people, they deals with electronics. I hope we'll have a great time together and you'll recapitulate, maybe learn, something useful. Why? Because I believe that a good knowledge of semiconductors is necessary for lot of jobs in electrotechnics.
Transistors, this is very large area and time limit is only five minutes. That's why I will say only the fast summary, without physical details.
And now, what's the matter:
What will be next about it?

- Well known transistor.
- Main groups of transistors
- Principle, or how they works?
- Used possibilities of connection
- The output diagram of CE connection

First of all, here is an brief overview of what I am going to talk about. After a quick introduction, we'll look at the main groups of transistors and their basic charakteristic. Then, in main part we'll deal with operation principle of bipolar transistors.
Because the transistor is real component part of some circuit, it's necessary have a look at connection possibilities.
And closing part - the output characteristic of the transistor in Common Emitter connection.
And, finally, we can discuss some other related topics if you wish.

Great Family of Transistors



We all are living in living environment, which is full of electronics. And electronics is not thinkable without semiconductors. Sure, were times, when were no semiconductors. In the past, were tubes in used. It was maybe romantic time, but electronic was only at the start. The tubes have some preferences, but they have some deficiencies. They were very large, like the finger and more. Besides, they produced lot of thermal energy. They were good as the heating too. By the using tubes in great quantities established great problems with their coolig and ventilating.

Modern semiconductors are very small, practically invisible and their heat production is negligible. This makes them possible for very large integration in electronical components. This integration then makes possibility of present-day electronics expansion.

Just transistor is the key component of electronics in all. Since 1947, when was the transistor discovered, were incurred the whole family of transistor kinds.

Some kinds of transistors are unipolar, the others are bipolar.

Bipolar or unipolar transistor? What is the diference?

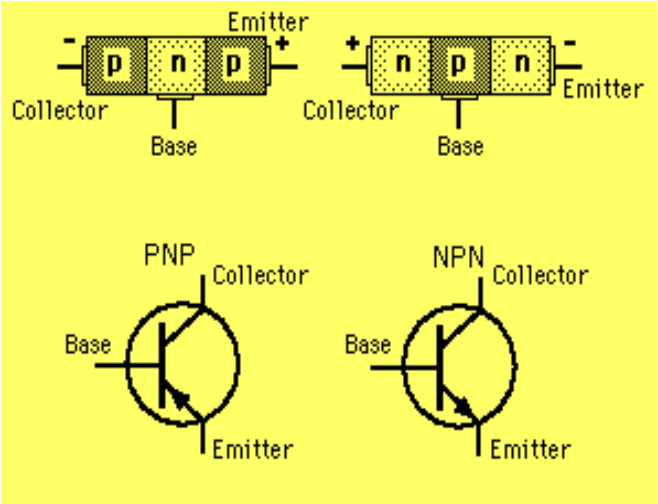
The name depends of kind of carriers. Evidently: different kinds of transistors are using different principles.

The transistors using for own conductivity only one kind of carriers – electrons are called unipolar. Unipolar transistors are using the principle of generation and control of current carrying canal inside the semiconductor.

The transistors which are using both carriers – electrons and holes, are called bipolar (or junction) transistors.

Bipolar transistors are using system consisting of two reverse coupling diodes, it means two PN junctions. One of them is controled.
Except these two types of transistors and theirs variations, are existing some special types, which combines both of previous transistors. For example is it IGBT transistor. Because the whole family of transistors is very large, is impossible to pay attention on all those types. This presentation is dedicated only for bipolar transistors, which are still mostly used.
Therefore for this presentation will be as the aim the bipolar transistors only.
Bipolar transistors:

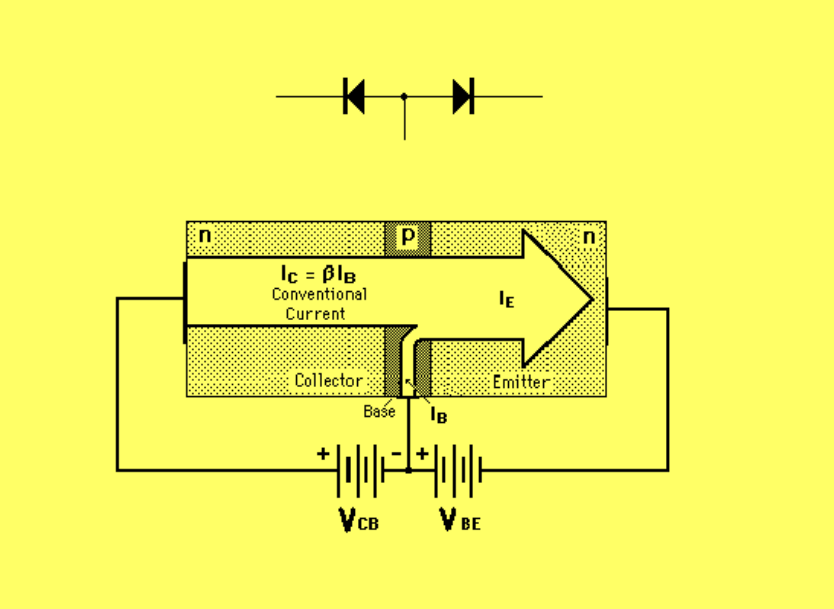
- Three layers structure
- Two classes: PNP or NPN
- Three terminals: Collector,Emitter,Base



And now, how looks the bipolar transistor inside.
A bipolar junction transistor consists of three regions of different doped semiconductors. There are two main possibilities. Transistor can consist of two regions type N and one region type P between them. The other possibility is two regions of P semiconductor and one region of type N.
Results of this structure are:
1) There exists two PN junctions. They are reverse polarized.
2) Each of regions inside the transistor has own terminal. The transistor as a semiconductor component has three terminals in all.
3) The sequence of regional names says the name of type transistor. Also we have NPN and PNP transistors.

Note: Each letter means one region in three layers structure – the same as the PN - junction. Here means the junction among regions doped on type N or P).

Structure of NPN transistor



So, double of reverse polarised PN junctions make in effect double of reverse connected diodes.

The Base - Emitter diode is forward-biased. The Base current is strongly dependent on the Base – Emitter voltage since it is a forward – biased diode. If the Base - Emitter voltage is positive and higher than 0,6 V, than Base -Emitter diode is on and Base- Emitter current can flow. The voltage 0,6 Volts is the treshold of conductivity for silicium diode.

On the contrary, the Base-Collector diode is reverse biased. Only minority carriers can cross the Collector - Base junction. But what kind of carrier is minority in the first region, after crossing the junction have to stay an opposite, majority. If the Base region is very thin, like 10 wavelengths of light, to facilitate passage through it. Also some 99% of the carriers injected into the base region are swept to the collector and Collector – Base junction is opening.

The larger collector current IC is proportional to the base current IB according to the relationship IC=βIB, or more precisely, it is proportional to the base-emitter voltage VBE . The smaller base current controls the larger collector current, achieving current amplification.

So very small current in the Base can be used to control much larger current flowing between Collector and Emitter. The device can be characterized as a current amplifier, having many applications for amplification and switching.

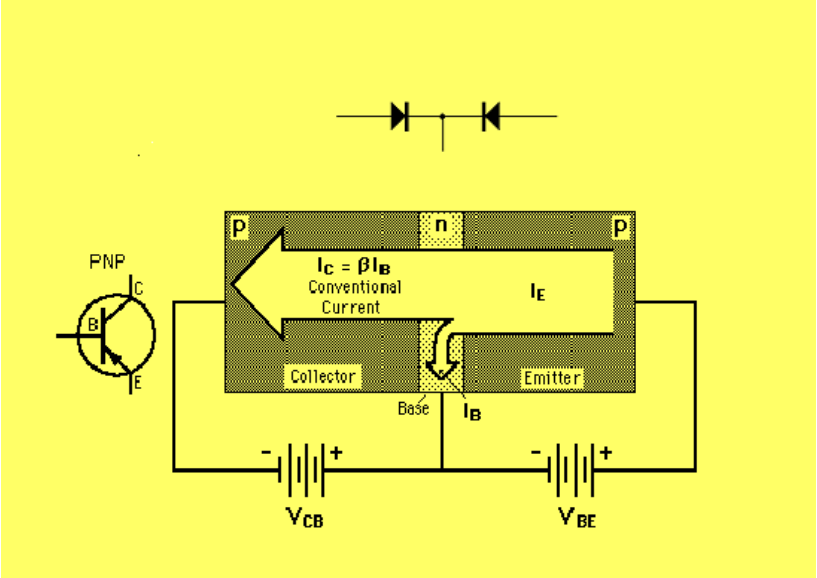
Now is clear, why transistor and double of diodes is not the same thing! If the Base region is thick, carriers can recombinate there and there is no current to open the closed CE junction more.

And what about the structure of transistor?

The collector region is the largest and is connected to a heat sink since it dissipates most of the heat in operation.

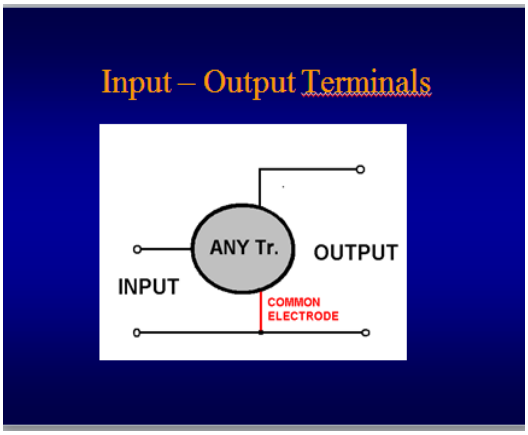
The Emitter region is smaller and more heavily doped to promote conduction.

PNP transistor - by PNP fast the same:



We can the situation apply by analogy by the NPN transistor.

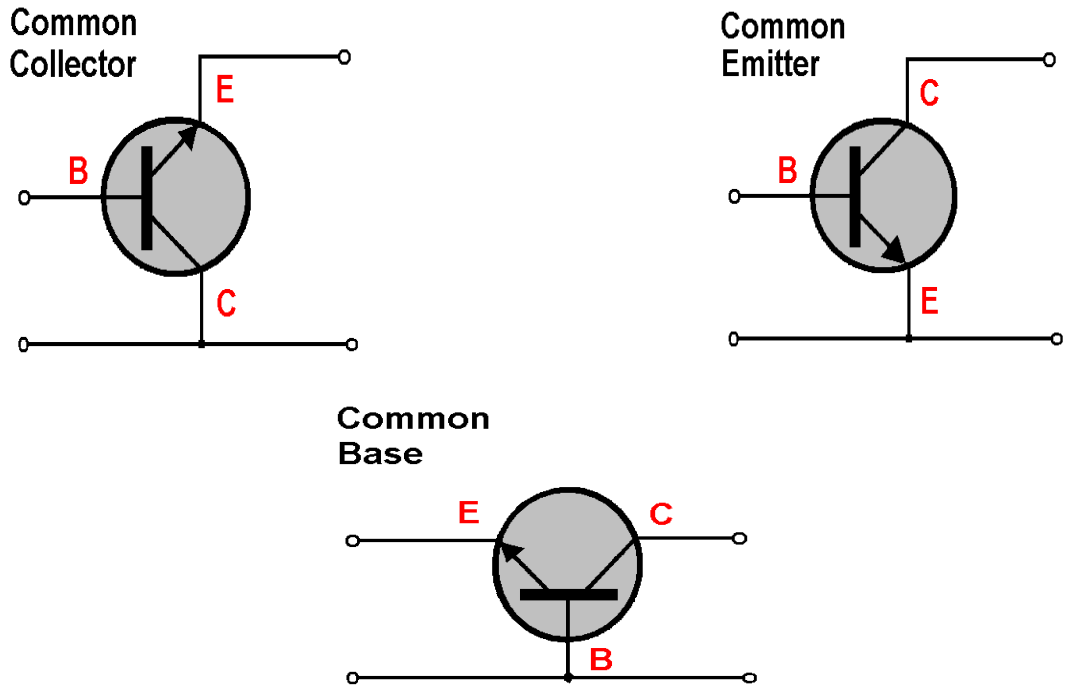
However the regions inside the transistor are changed. Then the opposite polarity of regions requires reversed polarity of voltage sources.



And how to connect the transistor device in the circuit?

Since a junction transistor is a three-terminal (or three electrode) device and there are needed four input-output terminals. Also, one of the transistor terminals must be common to the input and output circuits. This leads to the names Common Emitter, or Common Collector, or Common Base for the three basic types of circuit diagrams.

Connection - versions



Sure, this pictures are good only for imagination. For good functionality are necessary some resistors and sources.

Each of this configurations has own specifications and therefore their specific usage in electronics.

But this is the area over todays presentation.

Lets go to the connections:

Note: (CC means common collector, CB – common base, CE –common emitter).

NPN CC Mode:

The common collector amplifier, often called an emitter follower since its output is taken from the emitter resistor, is useful as an impedance matching device since its input impedance is much higher than its output impedance.

NPN CB Mode:

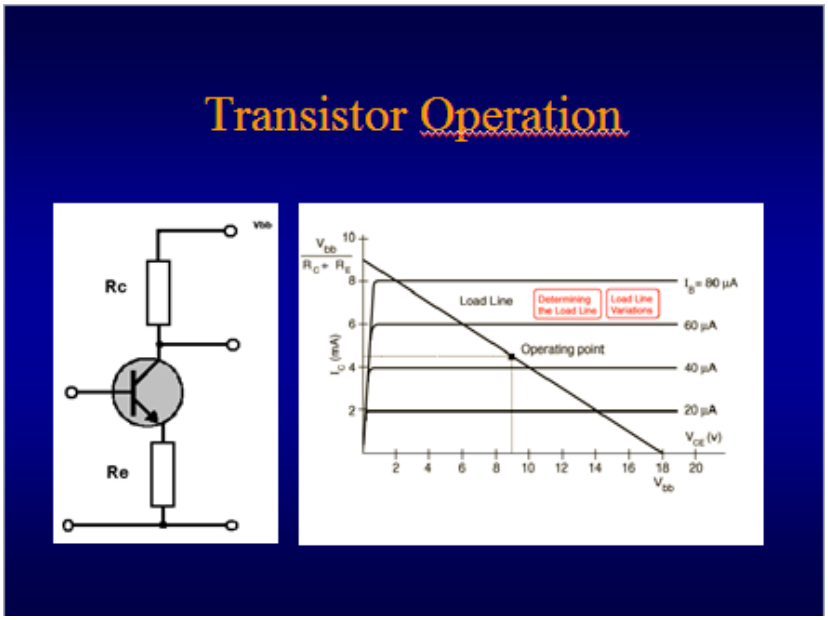
This configuration is used for high frequency applications because the base separates the input and output, minimizing oscillations at high frequency. It has a high voltage gain, relatively low input impedance and high output impedance compared to the common collector.

And mainly NPN CE Mode:

The common emitter configuration lends itself to power amplification and is the most used configuration for transistor amplifiers or switches.

Properties of such transistor can describe with using his characteristics.

Transistor Operation



Here is an example of output characteristic for transistor connected in most used common emitter mode:

The vertical axe shows the output current going through the collector in dependence on collector – emitter voltage. These curves tell you too, that the base current is essentially independent on the applied collector voltage. Here is the base current as parameter. There is only one curve for each value of this current. The larger collector

current IC is proportional to the base current IB according to the relationship IC=βIB. More precisely current Ic is proportional to the base-emitter voltage VBE . The smaller base current controls the larger collector current, achieving current amplification.

At the picture is the load line and the operating point on it. Set of all possible operating points create the load line. Position of load line can be changed by type of connecting. Inclination of load line is determined by voltage source and resistors connected in emitter and collector.

Consequently a transistor connected in a circuit with common emitter, can be in one of three conditions:

1. Cut off (no collector current), useful for switch operation. When base current is zero, then collector current will be zero too.
2. In saturation (collector near emitter in voltage, acting like a forward biased diode), large current useful for "switch on" applications. Transistor is turned on.
3. In the active region (some collector current, more than a few tenths of a volt above the emitter), collector current is directly proportional to the base current - useful for amplifier applications. The current and voltage will follow the load line.

It stands to reson, that the bipolar transistors can be used as the amplifiers or as the switches.

And this was the last information of today presentation.

Today you have heard:

1) A principle of the bipolar transistor.
2) Connecting possibilities of bipolar transistors.
3) The transistor operation for transistor type NPN in common emitter connection.

Bipolární tranzistory - Bipolar Transistors - slovníček odborných termínů

Vocabulary	Slovníček
carriers	nosiče
circuit	obvod
coupling diodes	spojené diody
current	proud
deals with electronics	zabývající se elektronikou
forward – biased	zapojený v propustném směru
junction	přechod
own conductivity	vlastní vodivost
semiconductors	polovodiče
terminal	vývod

Zdroje:

MAŤÁTKO, J., *Elektronika.* Idea Servis, 2008. ISBN 978-80-85970-64-7.

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