3.15: Transistors in 'forward active' mode

Common base circuit

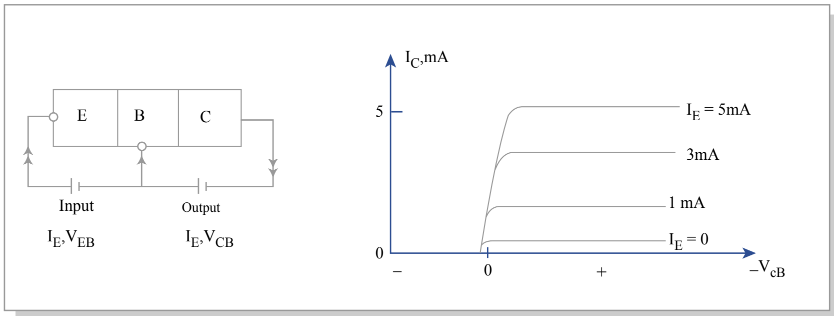

Figure by MIT OCW.

This is the easiest to visualize, though of limited usefulness. We use one power supply to put EB into forward bias (p side positive) and another one to put the BC into reverse bias (p side negative). The figure is drawn for a pnp transistor.

First, suppose we send a particular current I_E into the emitter (I_E is related of course to V_{EB}).This is shown as a family of curved lines, each corresponding to a different I_E. What happens as we vary V_{CB}? We know that all of the I_E current will be collected by the CB junction, provided that CB is in reverse bias. So the output, I_C, is the same as the input I_E for any value of reverse bias on CB, shown as the positive side of zero on the horizontal axis. In fact, CB will collect all of I_E even if CB is unbiased, due to the built-in voltage. So the output does not start to drop until we start to put forward bias onto CB, which prevents the collection of I_E (shown at the negative side of zero on the horizontal axis).

Suppose now we fix the voltage V_{CB} (dotted vertical line). This puts a fixed reverse bias onto CB. CB collects all of I_E so the output I_C is just equal to the input I_E. This does not provide any amplification.

Common emitter circuit

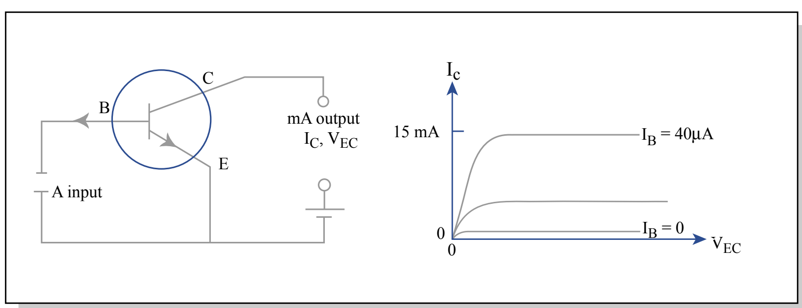

Figure by MIT OCW.

This is a more useful circuit because it gives amplification (the previous circuit did not amplify, because the output I_C was the same as the input I_E). Suppose we connect one input power supply that sends a current I_B between the base and the emitter. The polarity is chosen so that EB is in forward bias. We connect another power supply between E and C (this is chosen to make sure BC is in reverse bias).

The base current I_B is primarily composed of electrons that contribute to the forward current through EB. In the EB junction, there is a relation between the forward currents of holes and of electrons. These currents are in the ratios of the doping levels of the sides of the junction. If E is doped more heavily than B, a small electron current through EB implies that there is a large hole current through EB. This hole current is collected by the reverse biased BC junction, and flows through to make up the output current I_C. Therefore, a given I_B leads to a much larger I_C, with a gain of typically around 100 (that is, the ratio of doping levels in E and B). So to use this as a **current amplifier**, set a fixed V_{EC} (vertical dotted line), input I_B and you will produce an amplified output I_C.