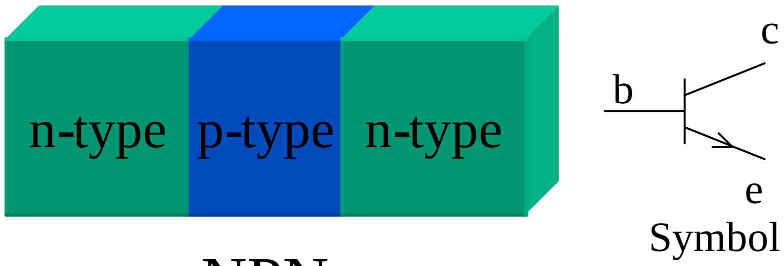
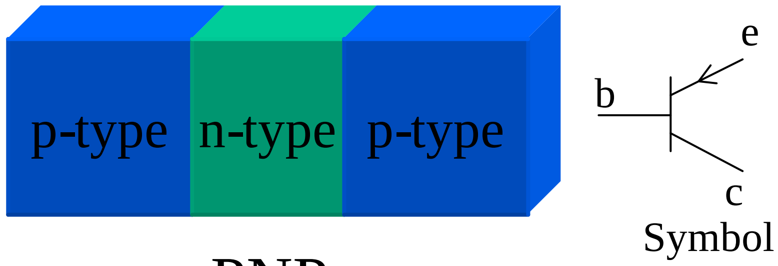
The Bipolar Junction Transistor

- The term *Bipolar* is because two type of charges (electrons and holes) are involved in the flow of electricity
- The term *Junction* is because there are two pn junctions
- There are two configurations for this device



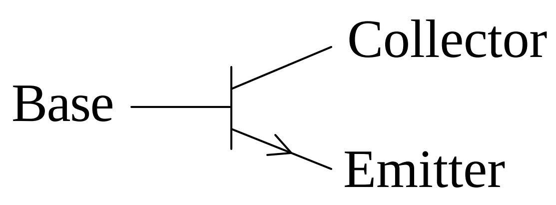
NPN

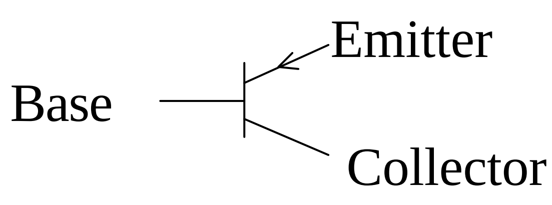


PNP

NPN and PNP Transistors

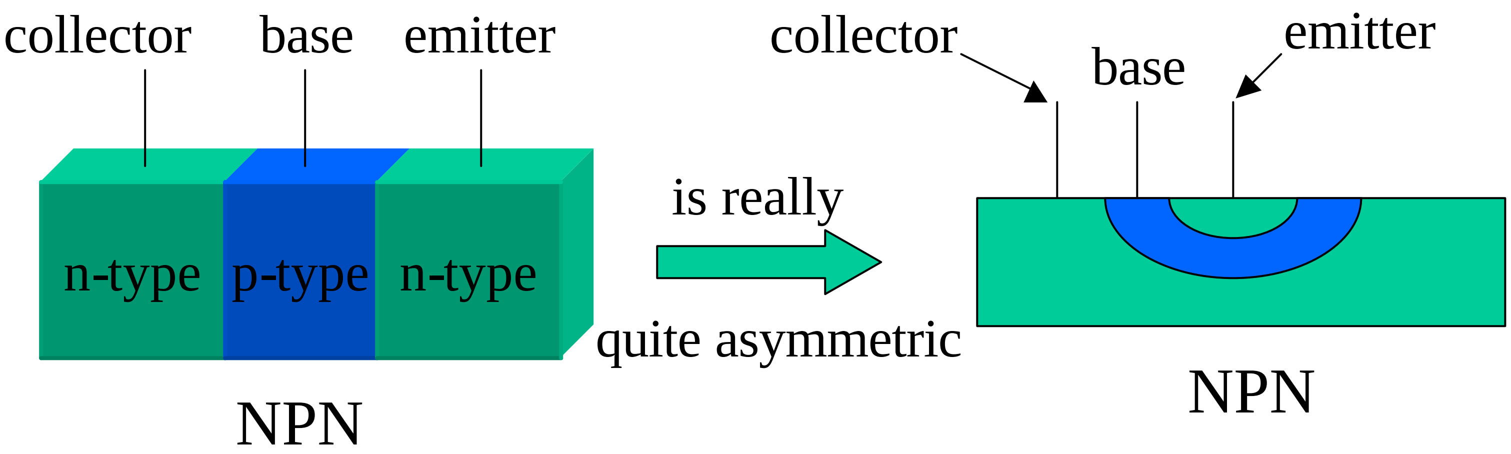
- NPN is more widely used
  - majority carriers are electrons so it operates more quickly
- PNP is used for special applications
  - we will concentrate on NPN
- The terminals of the transistor are labelled Base, Emitter, and Collector
  - The emitter is always drawn with the arrow.





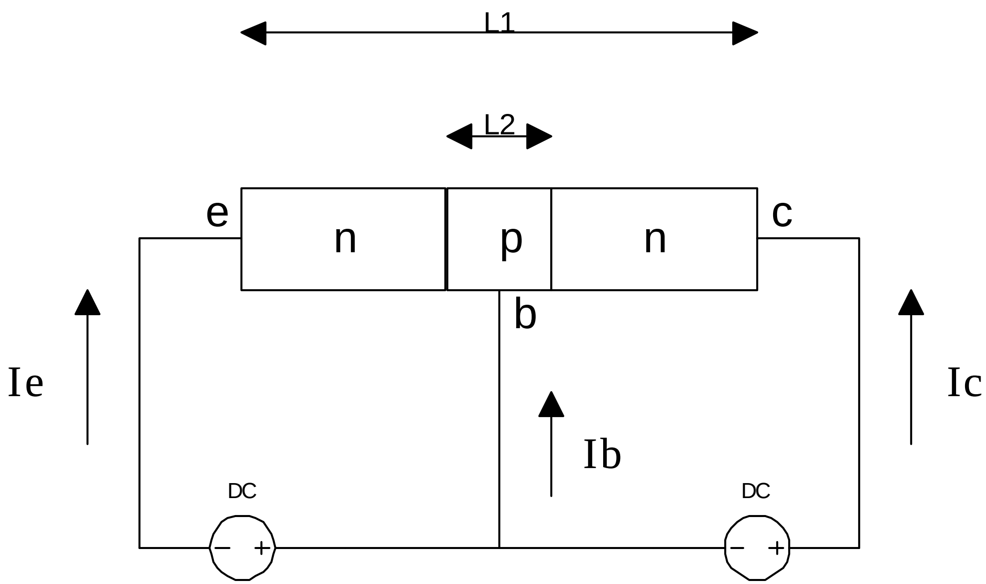
Asymmetry of Transistor

- Although in the NPN schematic, it looks like the collector and emitter can be reversed, in reality the device is very inefficient in reverse connection and has very little amplification (gain).



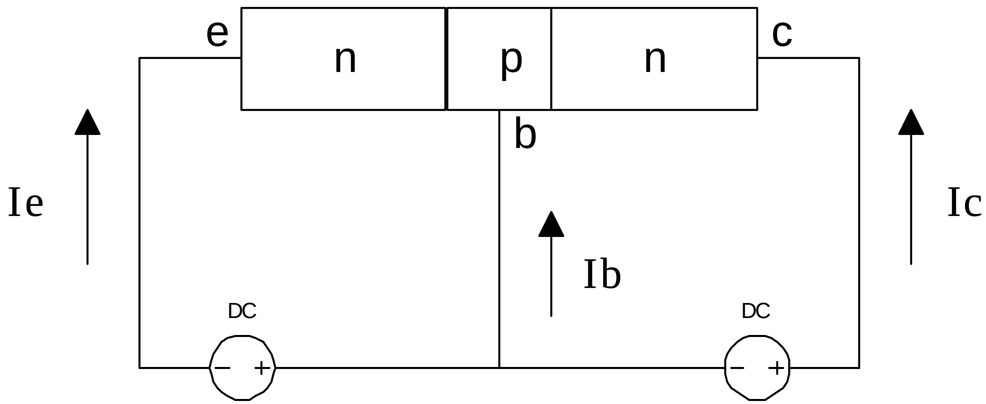
Operation of NPN Transistor

- In normal operation, the EB junction is forward biased and the BC junction is reverse biased
- The base region is very thin so the ratio L1:L2 is typically about 150:1



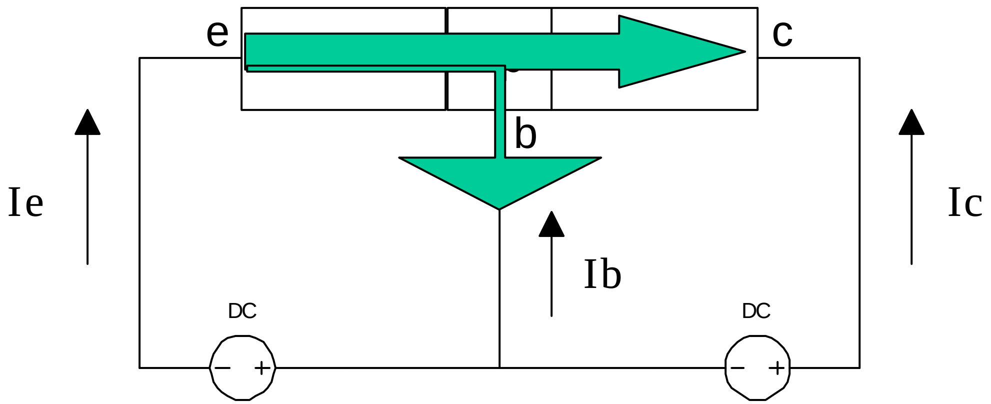
Behaviour

- Forward biasing of the EB junction causes a heavy flow of majority carriers (electrons) from the n-type material into the base junction and also majority carriers (holes) from the base region into the emitter region. We denote this current Ie.
- The transistor is made so that nearly all the current Ie consists of a flow of carriers (electrons) from emitter to the base. This is achieved by making the emitter much more heavily doped than the base.



Behaviour

- The base region is very thin so that most of the electrons attracted to this region pass straight through it (attracted by the collector which is positive relative to the base) before there is much chance of recombination with the base's holes.
- Because of this, the collector current is very nearly equal in value to I_e. Thus with the current directions shown $I_c = -\alpha I_e$ where α is close to unity (e.g., $\alpha = 0.98$).



Behaviour

- The current that does not go through the collector forms the base current so that we have Ib=-(1-α)Ie.
- From this

$$\frac{I_c}{I_b} = \frac{a}{1-a} = b$$

  Typically β=50 to 200
- The parameter β is called the DC current gain and represents the current amplification of the transistor.
- Indeed the use of the transistor as an amplifier is one of its main applications
- Another major application is using the transistor as a switch