

5.4.5. Temperature dependent effects in bipolar transistors

The temperature dependence of bipolar transistors depends on a multitude of parameters affecting the bipolar transistor characteristics in different ways.

First we will discuss the temperature dependence of the current gain. Since the current gain depends on both the emitter efficiency and base transport factor, we will discuss these separately.

The emitter efficiency depends on the ratio of the carrier density, diffusion constant and width of the emitter and base. As a result, it is not expected to be very temperature dependent. The carrier densities are linked to the doping densities. Barring incomplete ionization, which can be very temperature dependent, the carrier densities are independent of temperature as long as the intrinsic carrier density does not exceed the doping density in either region. The width is very unlikely to be temperature dependent and therefore also the ratio of the emitter and base width. The ratio of the mobility is expected to be somewhat temperature dependent due to the different temperature dependence of the mobility in n-type and p-type material.

The base transport is more likely to be temperature dependent since it depends on the product of the diffusion constant and carrier lifetime. The diffusion constant in turn equals the product of the thermal voltage and the minority carrier mobility in the base. The recombination lifetime depends on the thermal velocity. The result is therefore moderately dependent on temperature. Typically the base transport reduces with temperature, primarily because the mobility and recombination lifetime are reduced with increasing temperature. Occasionally the transport factor initially increases with temperature, but then reduces again.