The transistor as an amplifier

Using the previous example, we can see how the transistor can perform amplification. Originally, the input to the base of the transistor was a 1 volt DC source. Suppose that the input source could vary by plus or minus 0.1 volt. Since voltage sources in series add, we could represent this by a 0.2Vpp AC source in series with the original DC source. Our new Vin is the AC source and Vin' becomes the combined DC and AC input to the amplifier. The new amplifier circuit can be redrawn as shown below.



We see that in contrast to the original circuit, the input voltage to this amplifier varies from 0.9 volts to 1.1 volts. We define the gain of the amplifier as being $\Delta Vout/\Delta Vin$. To determine $\Delta Vout$, we apply 0.9V to the amplifier and then 1.1V and then take the differences between the output voltages. We analyze the amplifier as before below.

With an input (Vin') of 0.9V:

-0.9 + 10000Ib $+ 0.7 + 1000(\beta + 1)$ Ib = 0-0.9 + 10000Ib + 0.7 + 101000Ib = 0Ib $= 1.8\mu$ A. Therefore, Ic $= 100(1.8\mu$ A) $= 180\mu$ A; and therefore, Vout is 10 - 1.8 = 8.2V.

With an input (Vin') of 1.1V:

 $\begin{array}{l} -1.1 + 10000 \text{Ib} + 0.7 + 1000 (\beta + 1) \text{ Ib} = 0 \\ -1.1 + 10000 \text{Ib} + 0.7 + 101000 \text{Ib} = 0 \\ \text{Ib} = 3.6 \mu \text{A}. \\ \text{Therefore,} \\ \text{Ic} = 100 (3.6 \mu \text{A}) = 360 \mu \text{A}; \\ \text{and therefore, Vout is } 10 - 3.6 = \underline{6.4 \text{V}}. \end{array}$

Now we can determine the gain as $\Delta Vout/\Delta Vin$; where $\Delta Vout = (8.2 - 6.4)$ and $\Delta Vin = (0.9-1.1)$.

Gain =
$$\frac{\Delta \text{Vout}}{\Delta \text{Vin}} = \frac{(8.2 - 6.4)}{(0.9 - 1.1)} = \frac{1.8}{-0.2} = \underline{-9}$$

The gain of the amplifier is minus 9. The minus indicates that the amplifier is inverting the signal. In other words, if the input signal goes up in voltage, the output signal goes down.

We can visualize the operation of the amplifier better as a graph as shown below.



For this type of amplifier, you can usually "eyeball" the gain as a little less than: (collector resistor/emitter resistor) which is roughly 9.