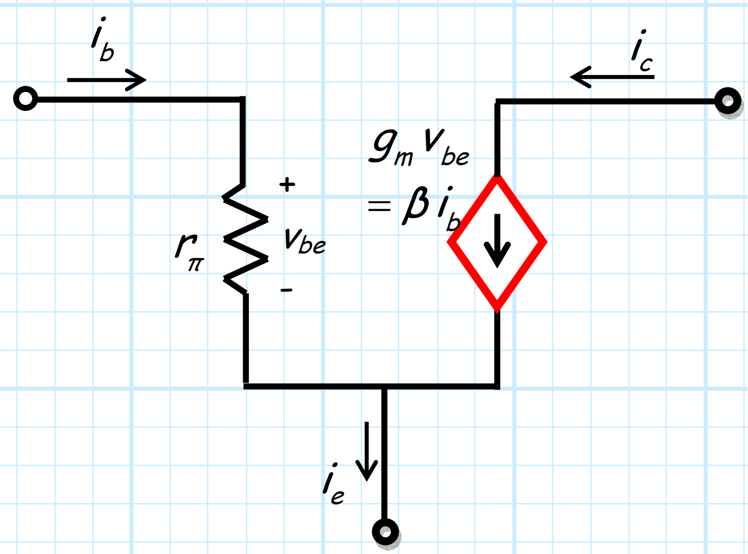
The Hybrid-Π and T Models

Consider again the small-small signal equations for an npn BJT biased in the active mode:

$$i_b = \frac{v_{be}}{r_\pi} \qquad i_c = g_m v_{be} = \beta i_b \qquad i_e = i_b + i_c \quad (KCL)$$

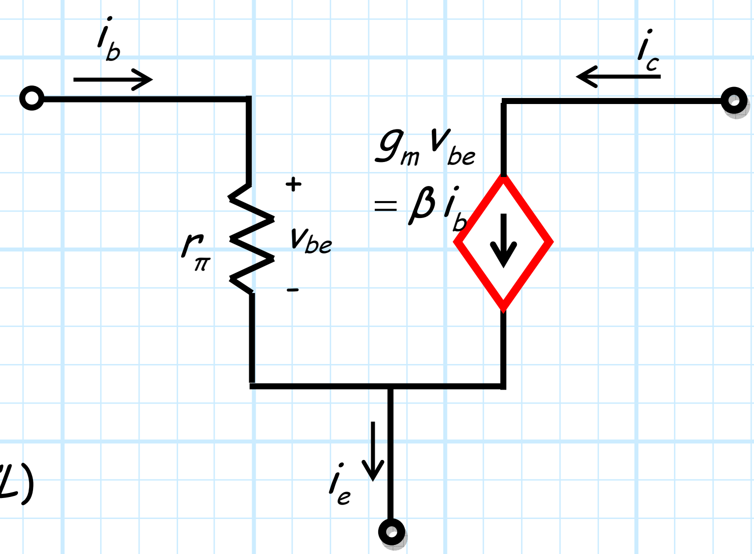
Now, analyze **this** circuit:



Do these equations look familiar?

From **Ohm's Law**:

$$i_b = \frac{v_{be}}{r_\pi}$$



From **KCL**:

$$i_c = g_m v_{be} = \beta i_b$$

And **also** from **KCL**:

$$i_e = i_b + i_c \qquad (KCL)$$

Q: *Hey! Aren't these the **same** three equations as the npn BJT **small-signal** equations?*

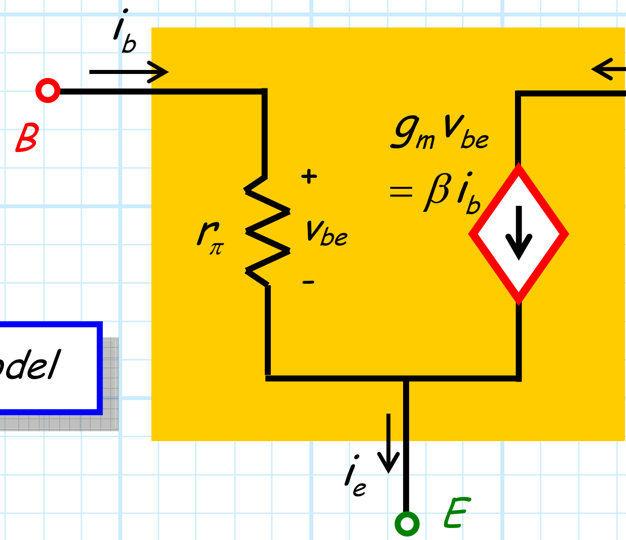
A: They **are** indeed!

With respect to the small-signal currents and voltages in a circuit (but **only** small-signal voltages and currents) , an *npn* BJT in active mode might as well be **this** circuit.

Two equivalent circuits

Thus, this circuit can be used as an **equivalent circuit** for BJT small-signal analysis (but **only** for small signal analysis!).

This equivalent circuit is called the Hybrid-Π model for a BJT biased in the **active** mode:

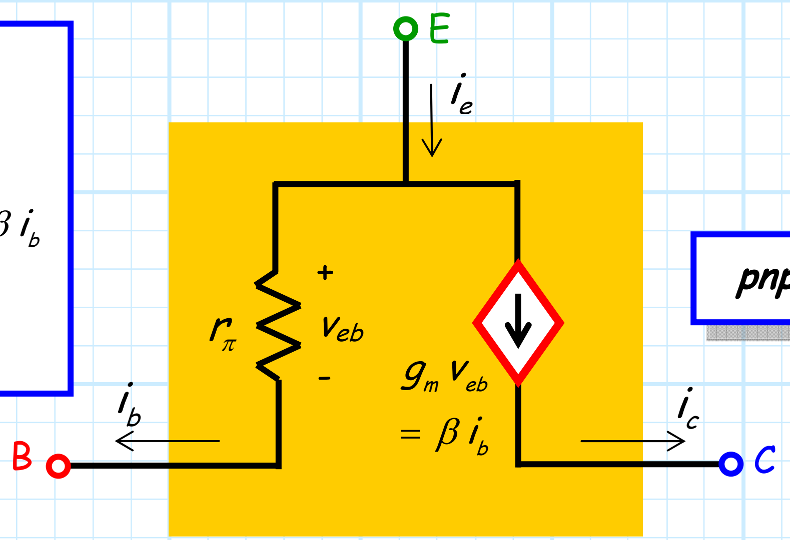


***npn** Hybrid-Π Model*

$$i_b = \frac{v_{be}}{r_\pi}$$

$$i_c = g_m v_{be} = \beta i_b$$

$$i_e = i_b + i_c$$



$$i_b = \frac{v_{eb}}{r_\pi}$$

$$i_c = g_m v_{eb} = \beta i_b$$

$$i_e = i_b + i_c$$

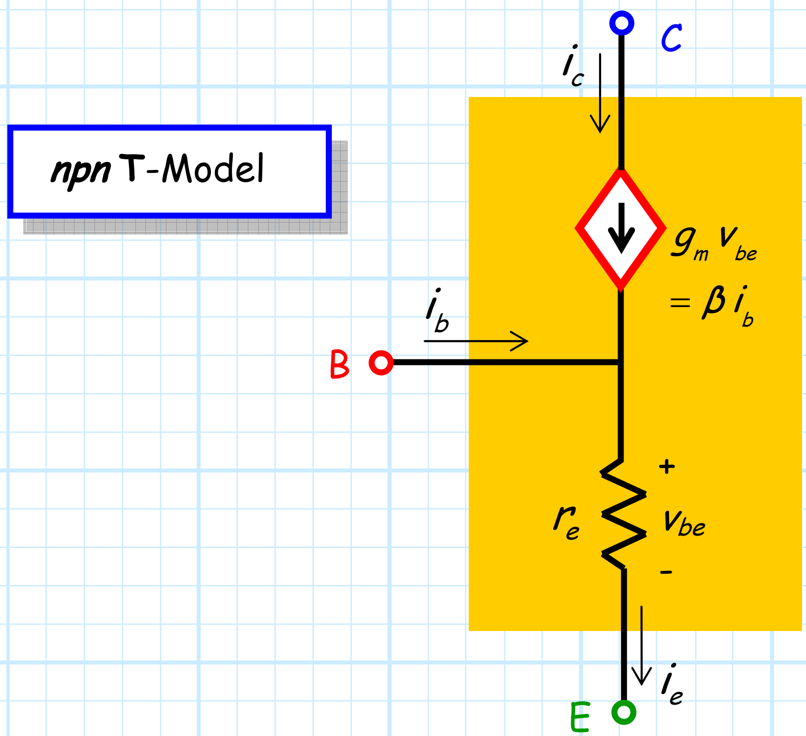
pnp Hybrid-Π Model

An alternative equivalent circuit

Note however, that we can **alternatively** express the small-signal circuit equations as:

$$i_b = i_e - i_c \qquad i_c = g_m v_{be} = \beta i_b \qquad i_e = \frac{v_{be}}{r_e}$$

These equations likewise describes the **T-Model**—an **alternative** but **equivalent** model to the Hybrid-Π.

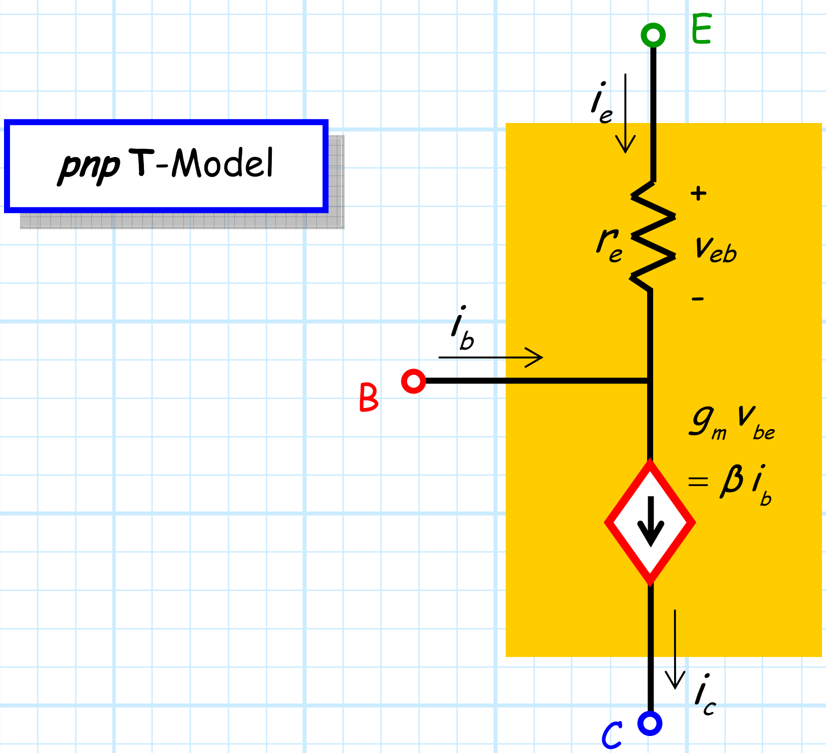


$$i_b = i_e - i_c$$

$$i_c = g_m v_{be} = \beta i_b$$

$$i_e = \frac{v_{be}}{r_e}$$

I just couldn't fit the *pnp* T-model on the previous page



$$i_b = i_e - i_c$$

$$i_c = g_m v_{eb} = \beta i_b$$

$$i_e = \frac{v_{eb}}{r_e}$$

So many choices; which should I use?

The Hybrid-Π and the **T** circuit models are equivalent—they **both** will result in the **same** correct answer!

Therefore, you do **not** need to worry about which one to use for a particular small-signal circuit analysis, **either one** will work.

However, you will find that a particular analysis is **easier** with one model or the other; a result that is dependent **completely** on the type of amplifier being analyzed.

For time being, use the **Hybrid-Π model**; later on, we will discuss the types of amplifiers where the **T**-model is simplest to use.