Last Lecture → BJT: Large Signal Analysis

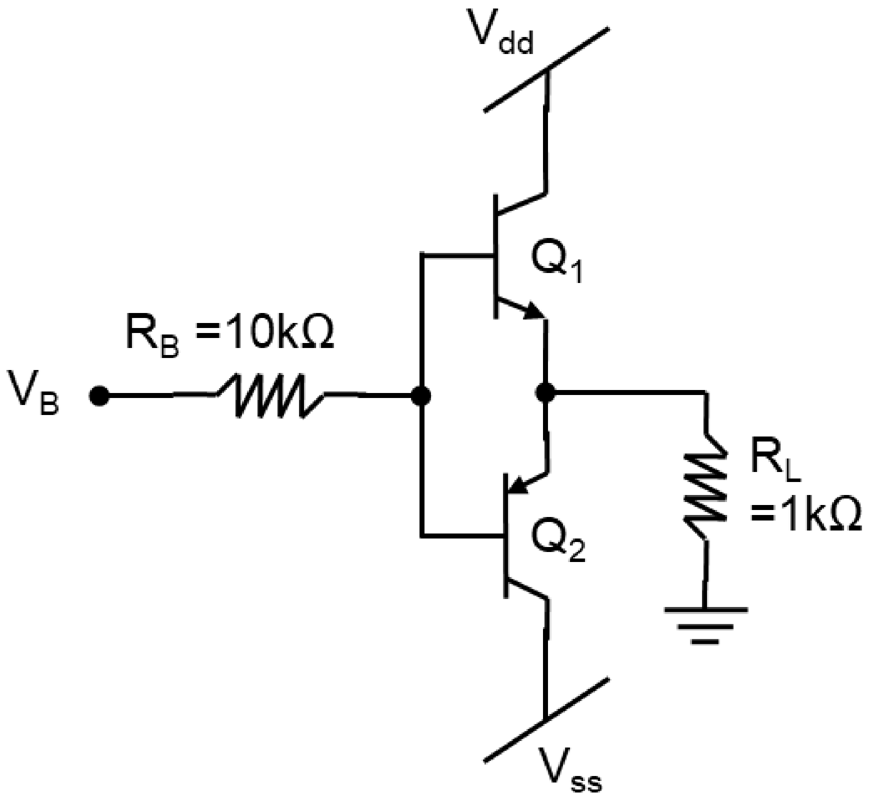
1) When applicable, simplify the circuit
2) Determine if BE/EB junction is forward (transistor = "on")
   - If reverse, transistor → cut off
   - If forward, transistor → active / saturation

     ∴ Make an educated guess of the region of operation
3) Substitute the appropriate model and or assumptions
4) Solve for the transistor operating point (I_C & V_{CE})
5) Verify proper operation @ the assumed region
   - If cut off → $V_{BE} < 0.5V$
   - If active → $V_{BE} >= 0.5V$, $V_{CE} >= 0.3V$
   - If saturation → $V_{BE} >= 0.5V$, $I_C / I_B < \beta$

Example 6.12

For the following circuit determine the voltages at all nodes and the current through all branches assuming:

a) V_{BE}=0.7V, β=100, V_{dd} = -V_{ss} =5V, and V_B =5V
b) V_{BE}=0.7V, β=100, V_{dd} = -V_{ss} =5V, and V_B =0.3V



Example 6.11

For the following circuit determine the voltages at every node and the bias currents of transistors Q_1 and Q_2. Assume $V_{BE}=|V_{EB}|=0.7$ and $\beta=100$.

KVL V_{be} of Q_1 (with Thevenin equivalent circuit)

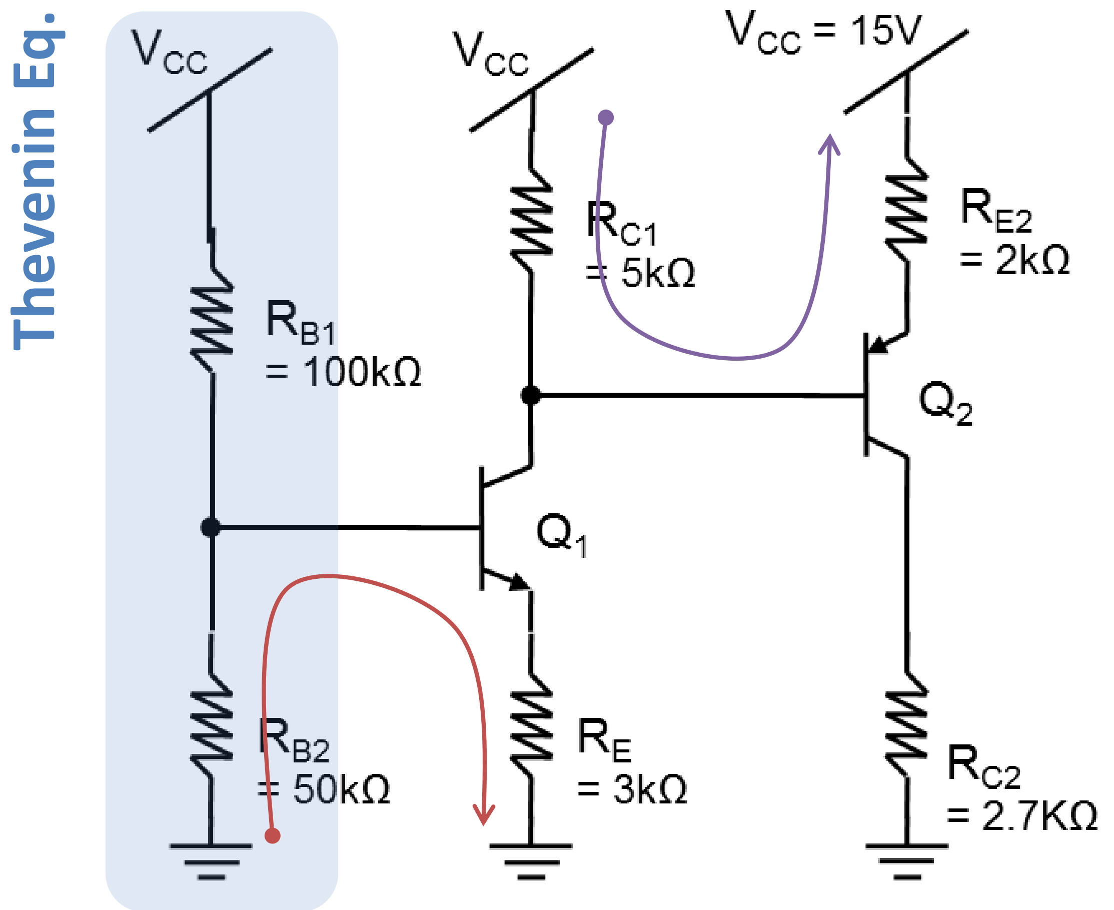
$$V_{th} = R_{th} \cdot I_1 + V_{BE1} + R_{E1} \cdot I_{E1}$$

$$\rightarrow I_{B1} = 12.8\mu A$$

KVL V_{eb} of Q_2

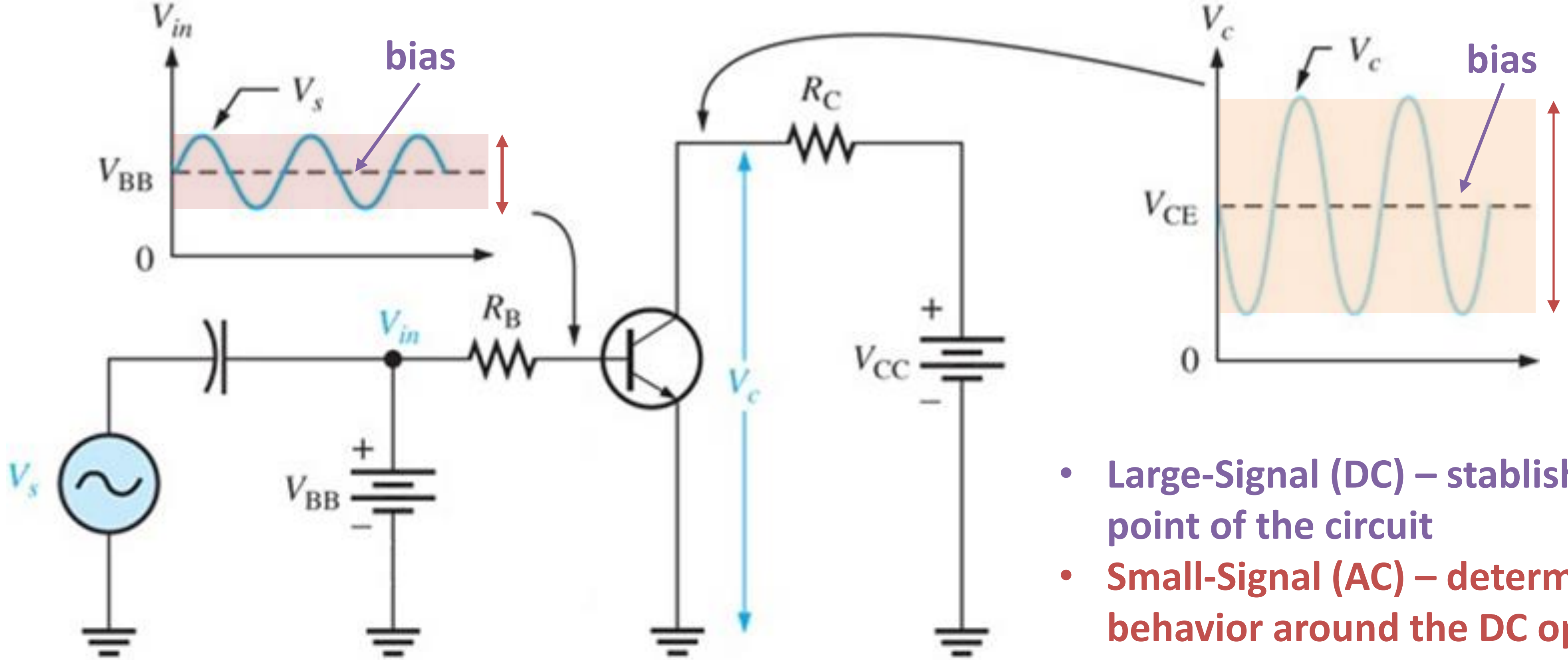
$$R_{C1} \cdot [I_{C1} - I_{B2}] = V_{EB2} + R_{E2} \cdot I_{E2}$$

$$\rightarrow I_{B2} = 27.5\mu A$$



Large-Signal vs Small Signal Behavior

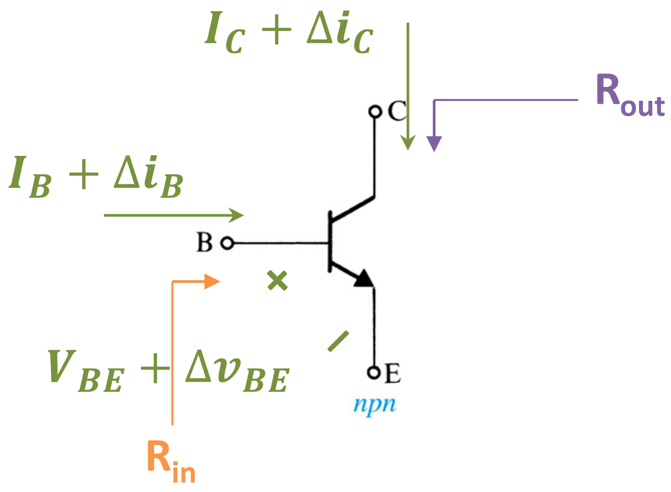
- Bias current is stablished through V_{BB} and supplied by V_{cc}
- AC signal is coupled through the capacitor and superimposed to the DC signal



AC & DC analysis can be performed via superposition!

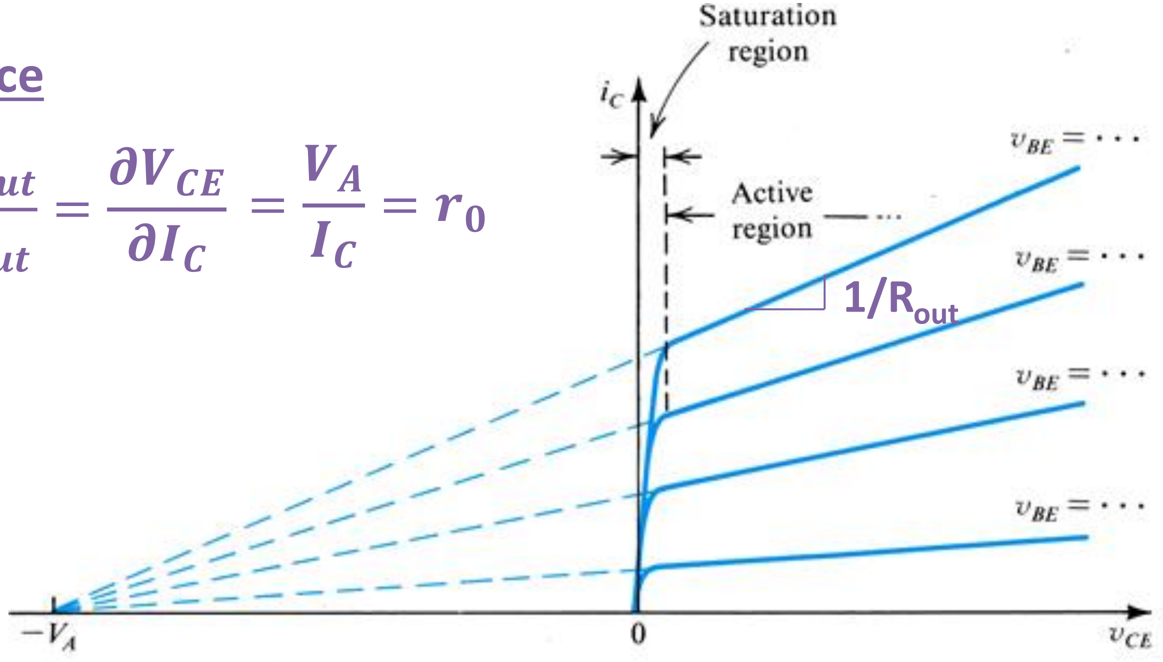
- Large-Signal (DC) – stablishes the DC operating point of the circuit
- Small-Signal (AC) – determines de circuit behavior around the DC operating point

Small Signal Parameters

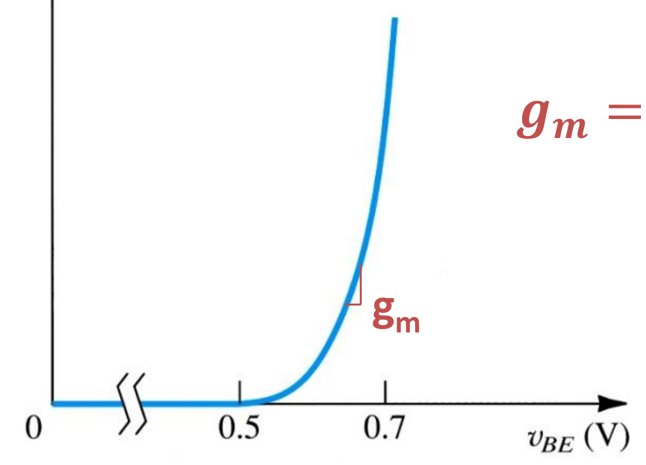


Output Impedance

$$R_{out} = \frac{\partial V_{out}}{\partial I_{out}} = \frac{\partial V_{CE}}{\partial I_C} = \frac{V_A}{I_C} = r_0$$



Trans-conductance



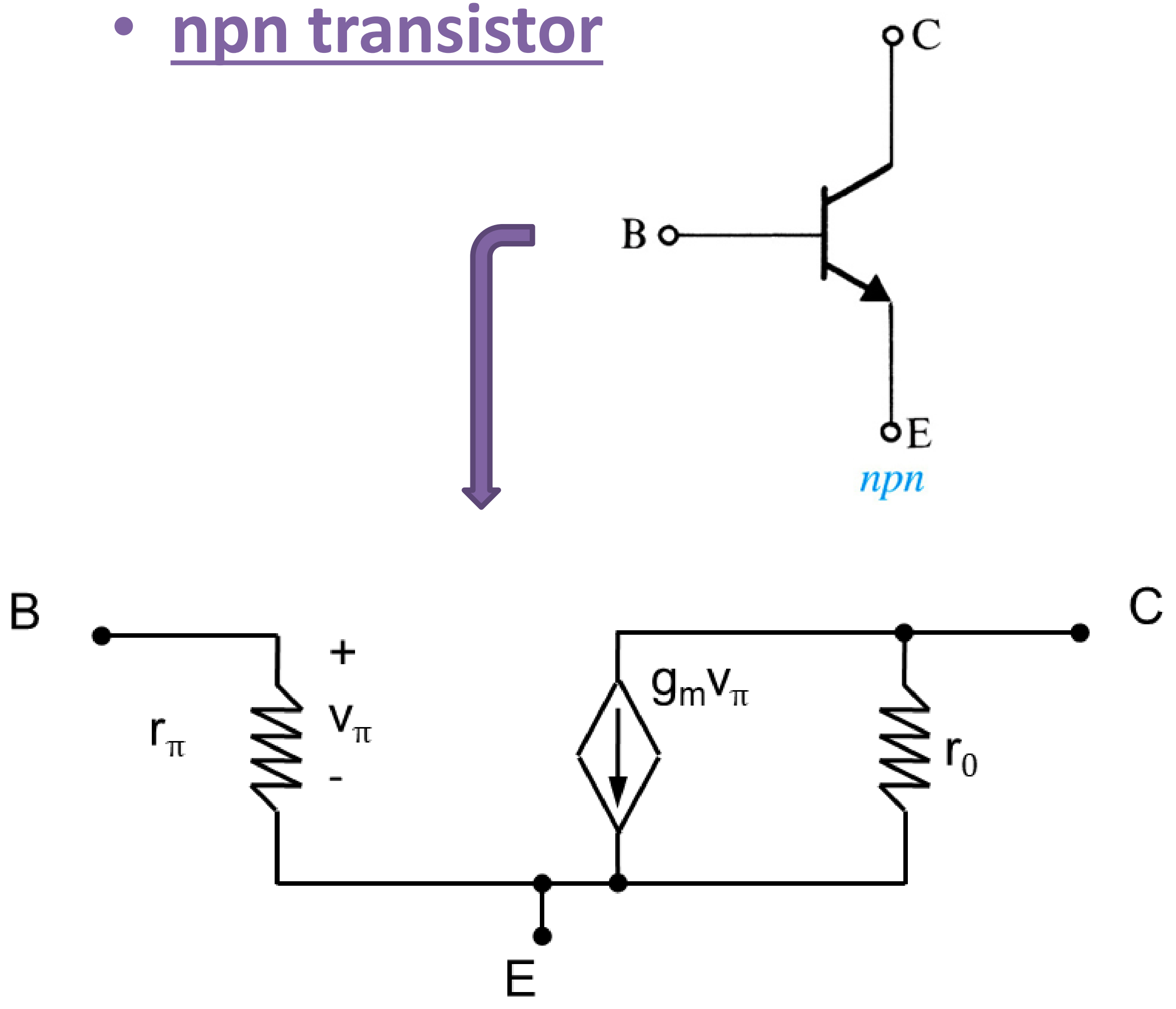
$$g_m = \frac{\partial I_{out}}{\partial V_{in}} = \frac{\partial I_C}{\partial V_{BE}} = \frac{I_C}{V_T}$$

Input Impedance

$$R_{in} = \frac{\partial V_{in}}{\partial I_{in}} = \frac{\partial V_{BE}}{\partial I_B} = \frac{\beta}{g_m} = r_\pi$$

Small Signal Equivalent Circuit

- **npn transistor**



- **pnp transistor**