ECE 65: Components & Circuits Lab

Lecture 11

BJT circuits

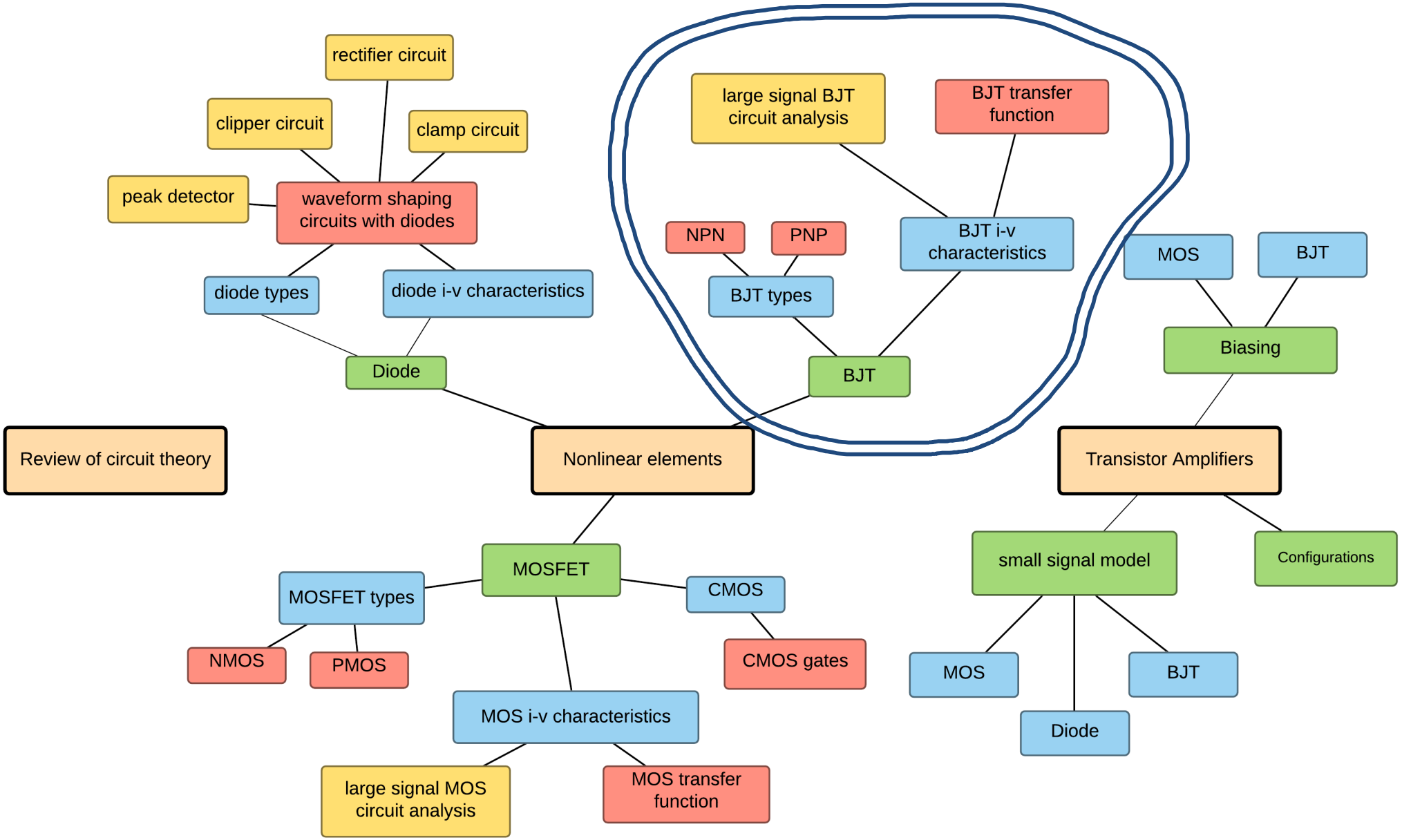
Reference notes: sections 3.2

Sedra & Smith (7th Ed): sections 6.1-6.3

Saharnaz Baghdadchi

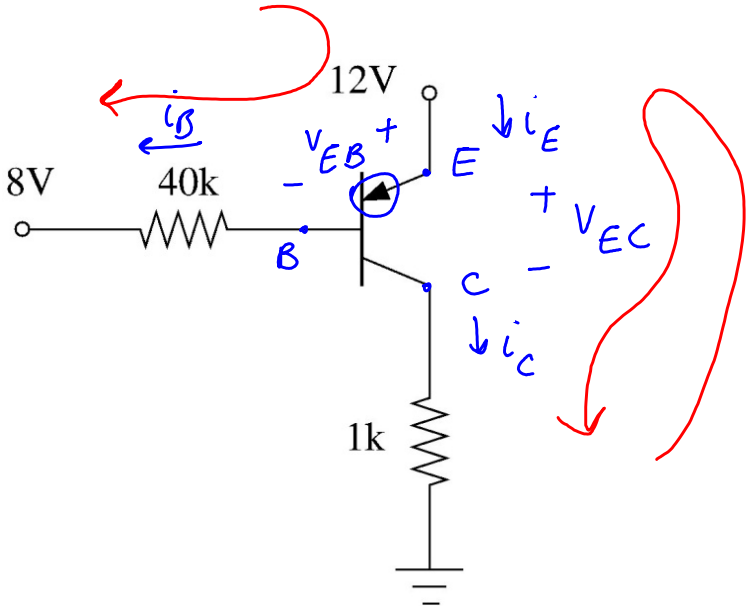
Course map

3. Bipolar Junction Transistor (BJT)



PNP Transistor Example:

In this circuit, find the transistor parameters (Si BJT with $\beta = 100$).



EB KVL:

$12 = V_{EB} + 40k \times i_B + 8$

$4 = V_{EB} + 40k \times i_B$

EC KVL:

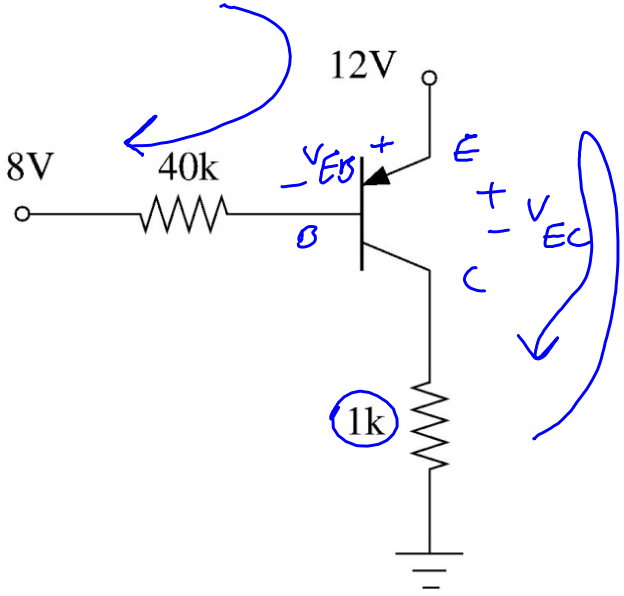
$12 = V_{EC} + 1k \times i_C$

Assume the BJT is in cut-off, $i_B = 0$, $V_{EB} < V_{D_0} = 0.7V$

EB KVL: $4 = V_{EB} + 40k \times 0 \longrightarrow V_{EB} = 4V > 0.7 \longrightarrow$ BJT is not in cut-off

BJT is ON, $i_B \geq 0$, $V_{EB} = V_{D_0} = 0.7\ V$

EB KVL, $4 = 40K \times i_B + 0.7 \longrightarrow i_B = 82.5\ \mu A > 0$



Assuming active mode:

$i_C = \beta i_B$, $V_{EC} \geq V_{D_0} = 0.7\ V$

$i_C = 100 \times 82.8\ \mu A = 8.25\ mA$

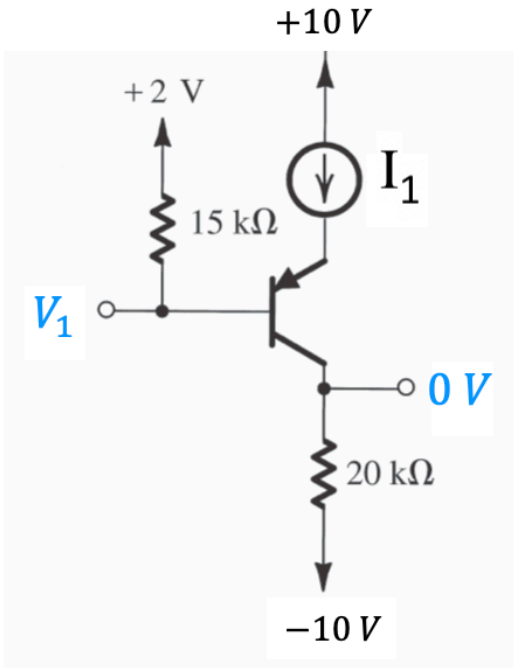
EC KVL: $12 = V_{EC} + 10^3 \times 8.25 \times 10^{-3} \longrightarrow V_{EC} = 3.75\ V > 0.7$

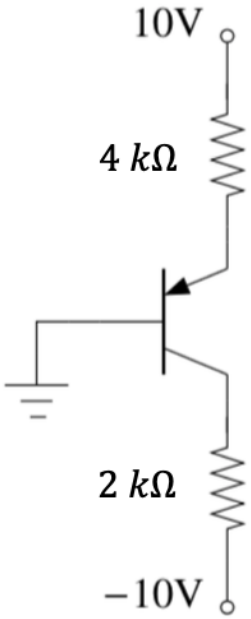
Assumption was correct, BJT is in active mode.

Note:

In the BJT and MOSFET circuits, to differentiate the applied node voltages from the measured node voltages:

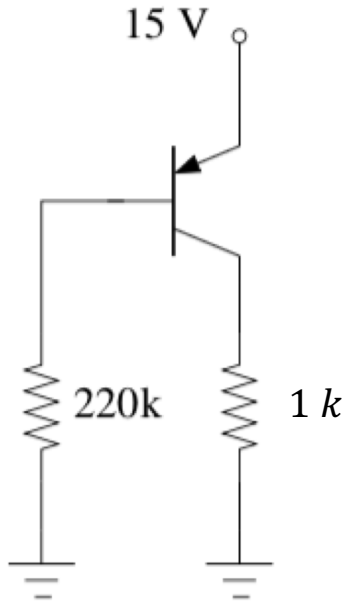
We will show the measured node voltages in **blue color** and the applied DC or AS voltage sources to different nodes in **black color**.





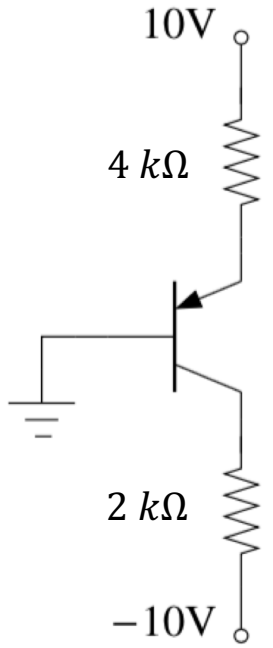
Lecture 11 reading quiz

Find the transistor parameters in this BJT circuit. ($\beta = 100$, $V_{D0} = 0.7V$).



Clicker question 1:

The transistor in the following circuit has $\beta = 100$. Find the value for V_{EC}. (assume $V_{D0} = 0.7V$, $V_{sat} = 0.2\,V$).



A. $V_{EC} \approx 10.5\,V$

B. $V_{EC} = 0\,V$

C. $V_{EC} \approx 6.1\,V$

D. $V_{EC} = 0.2\,V$

Cut-off :	**Active:**	**Saturation:**
$i_B = 0, \quad i_C = 0$	$v_{EB} = V_{D0}, \quad i_B \geq 0$	$v_{EB} = V_{D0}, \quad i_B \geq 0$
$v_{EB} < V_{D0}$	$i_C = \beta\, i_B, \quad v_{EC} \geq V_{D0}$	$v_{EC} = V_{sat}, \quad i_C < \beta\, i_B$

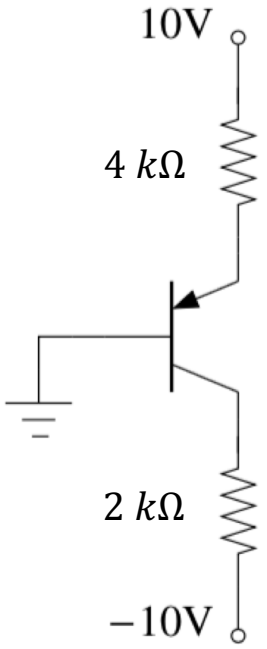
Hints:

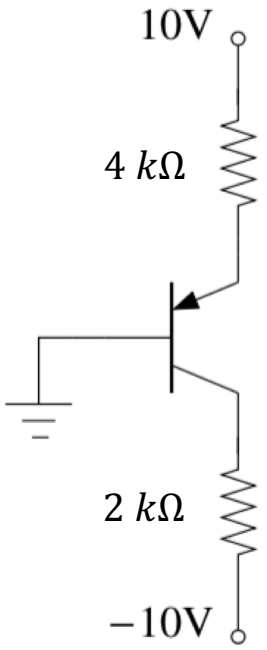
- Write the EB KVL and test if the BJT is in cut-off.

- If the BJT is ON, you can either assume active mode of operation or saturation mode of operation.

- If you assume active mode, you can use the relationship between I_C and I_B, the EC KVL, and the KCL relating the BJT currents to find V_{EC}, compare it with V_D0, and confirm or reject your assumption. You can replace the DC sources (10 V and -10 V with the symbol of a DC voltage source and explicitly draw the grounds.

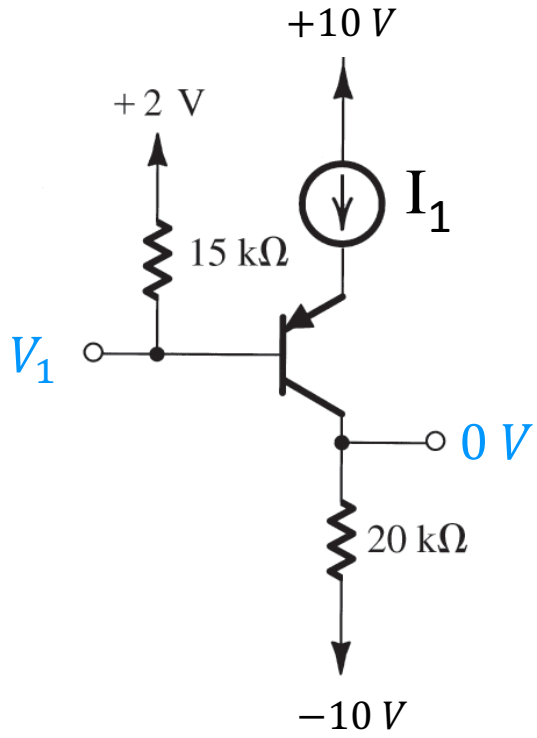
- If you assume saturation mode, you can use V_{EC}=V_{sat} and the EC KVL to find I_C. Compare I_C with I_B and confirm or reject your assumption.




10V
4 kΩ
2 kΩ
−10V

Discussion question 1:

In this BJT circuit find V_1 and I_1. Assume $\beta = 100$, $V_{D0} = 0.7V$, $V_{sat} = 0.2\,V$.



Cut-off :	Active:	Saturation:
$i_B = 0, \quad i_C = 0$	$v_{EB} = V_{D0}, \quad i_B \geq 0$	$v_{EB} = V_{D0}, \quad i_B \geq 0$
$v_{EB} < V_{D0}$	$i_C = \beta\, i_B, \quad v_{EC} \geq V_{D0}$	$v_{EC} = V_{sat}, \quad i_C < \beta\, i_B$

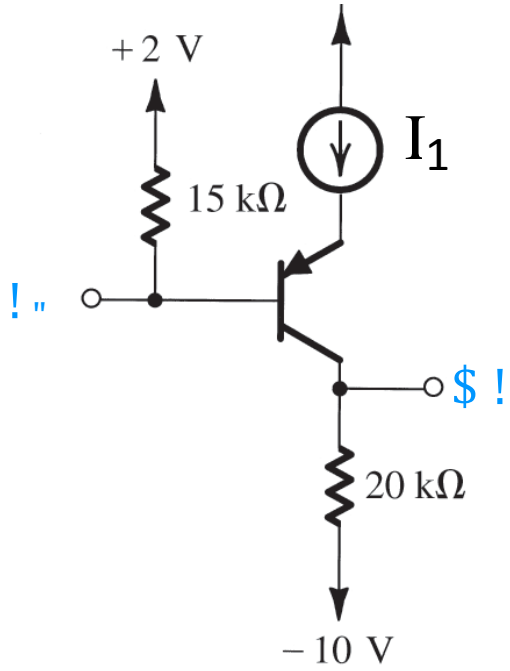
Hints:

- Find the collector current and use it to determine if the BJT is ON or in Cut-off.

- If it is ON, you can assume active mode of operation, and find I_B and I_E. You will need to verify this assumption by finding V_{EC}.

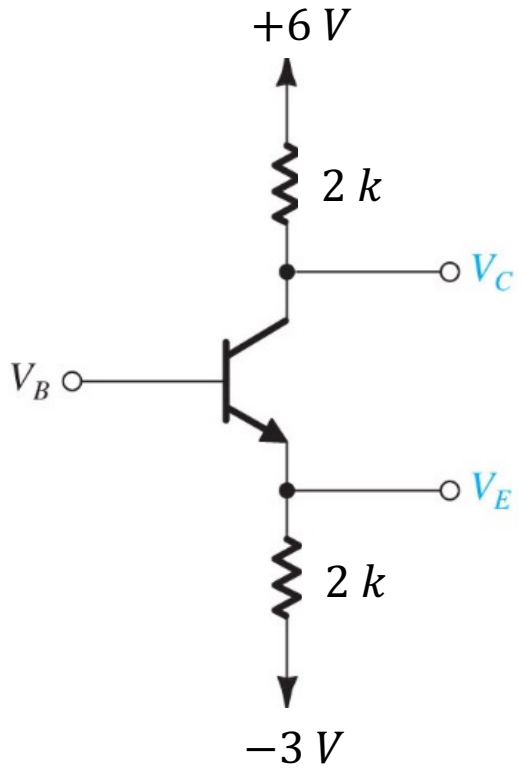
- Using I_B, you can find V_B and using V_{BE}, you can find V_E. If the PNP BJT is ON, V_{EB}=0.7 V.

- Note that the voltage drop across the current source will be non-zero.



Discussion question 2:

Consider the operation of the below circuit for V_B at -1 V and 1V. Assume $V_{D0} = 0.7V$ and $\beta = 100$. What are the values of V_E and V_C ?



Cut-off :	**Active:**	**Saturation:**
$i_B = 0, \quad i_C = 0$	$v_{BE} = V_{D0}, \quad i_B \geq 0$	$v_{BE} = V_{D0}, \quad i_B \geq 0$
$v_{BE} < V_{D0}$	$i_C = \beta\, i_B, \quad v_{CE} \geq V_{D0}$	$v_{CE} = V_{sat}, \quad i_C < \beta\, i_B$