Lesson 14&15

BJT Small-Signal Model 1,2

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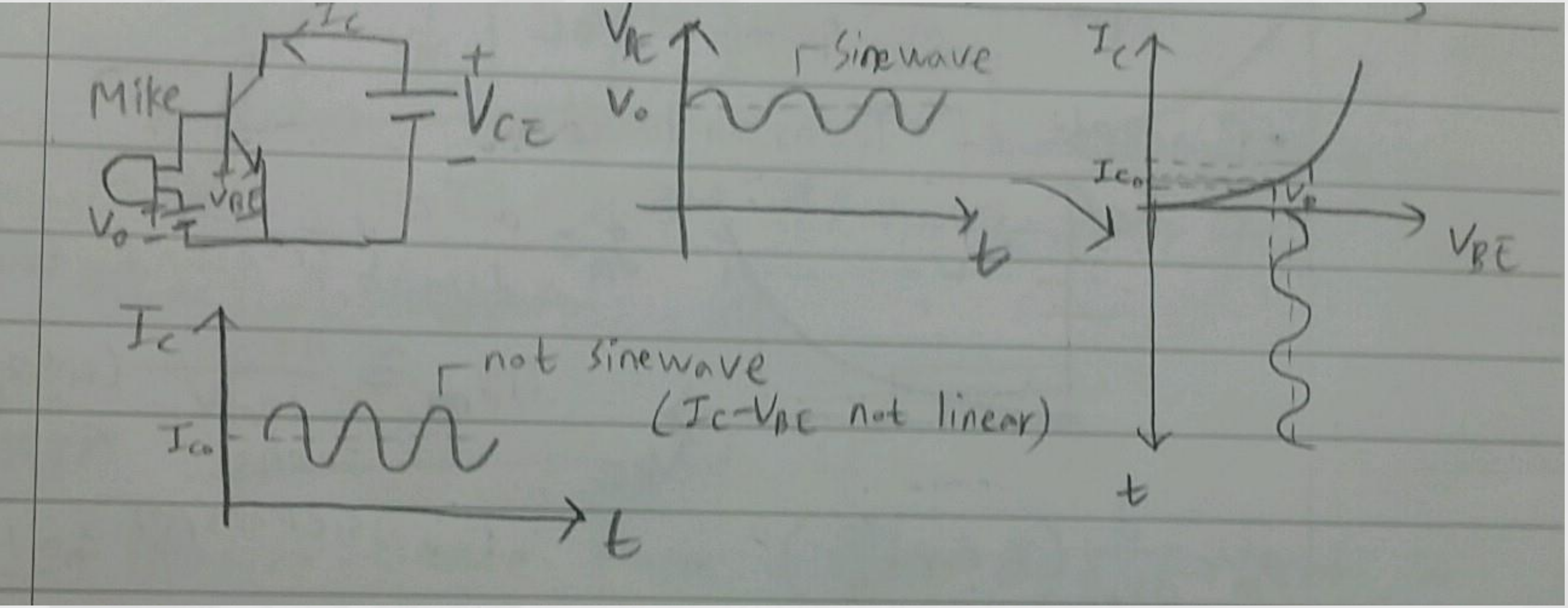
*Combining Time Response with I,V Characteristics

YouTube
Lecture 16



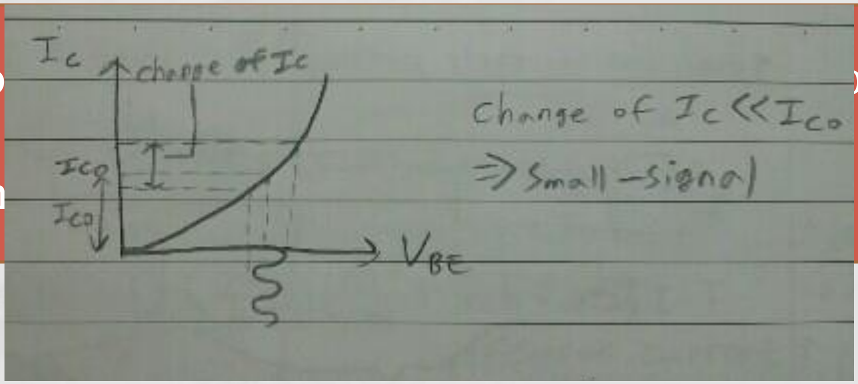
*Large-Signal and Small-signal

·We have to think about "Small-signal" operation for pervious page.

Large-Signal operation : the signal is arbitrarily large
=>Change of I_C is larger than I_{C0}

Small-Signal operatio ... nly a

=>Ch



*Combining Time Response with I,V Characteristics in Small-Signal operation 1

·In page 2, we know $I_C = I_S exp\frac{V_o+V_m sinwt}{V_T}$.

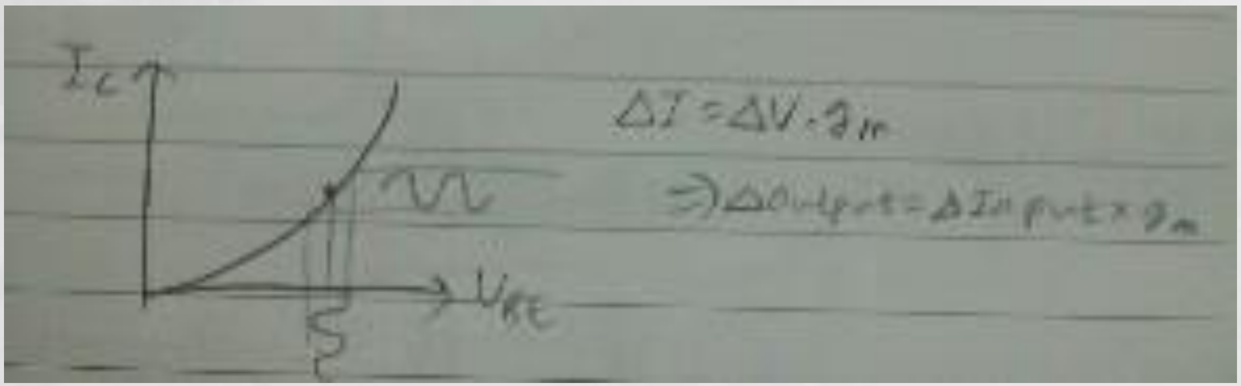
$$\approx I_S exp\frac{V_O}{V_T}(1+\frac{V_m sinwt}{V_T}) \quad (e^{\varepsilon} \approx 1+\varepsilon \text{ if } \varepsilon \ll 1)$$

$$=I_{C0}+\boxed{\frac{I_{C0}}{V_T}}V_m sinwt$$

↓

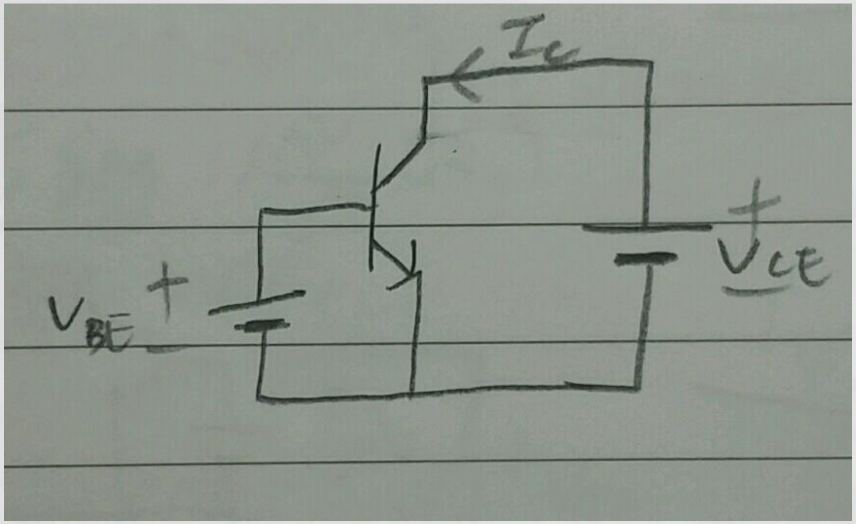
g_m

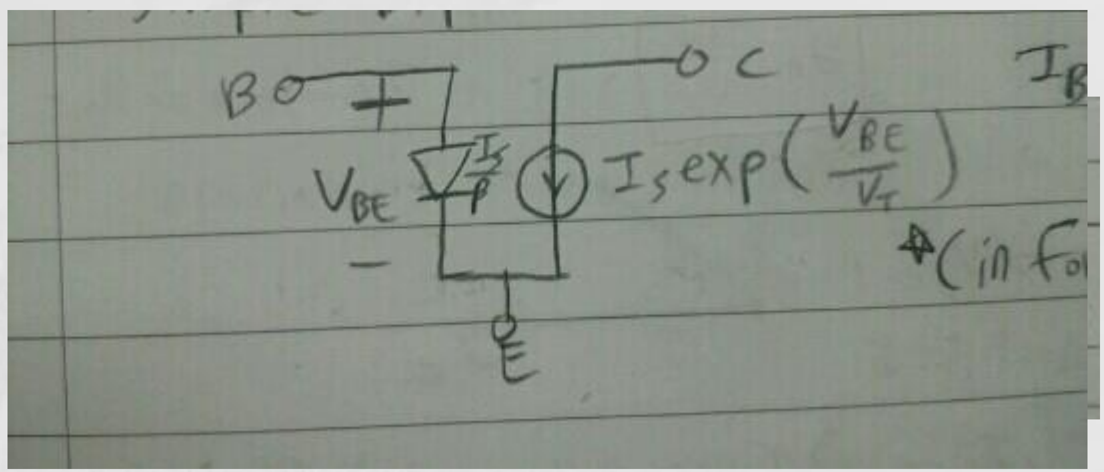
*Combining Time Response with I,V Characteristics in Small-Signal operation 2



Linear!

*Simple Bipolar Transistor Model





*Small-Signal Model 1

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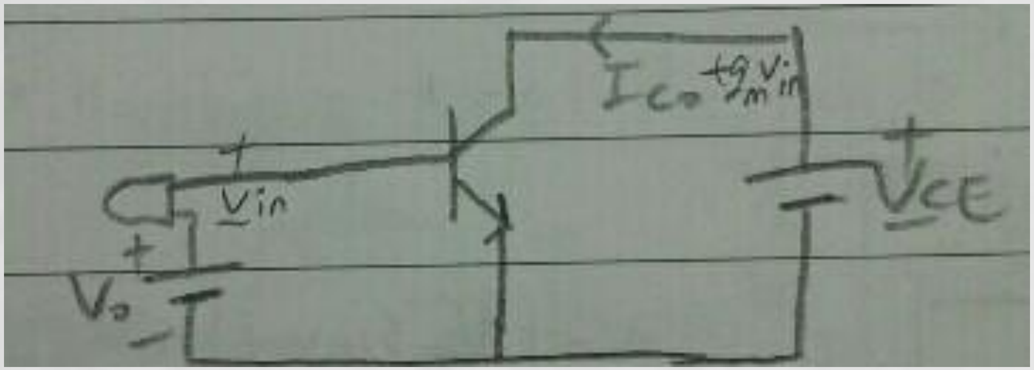
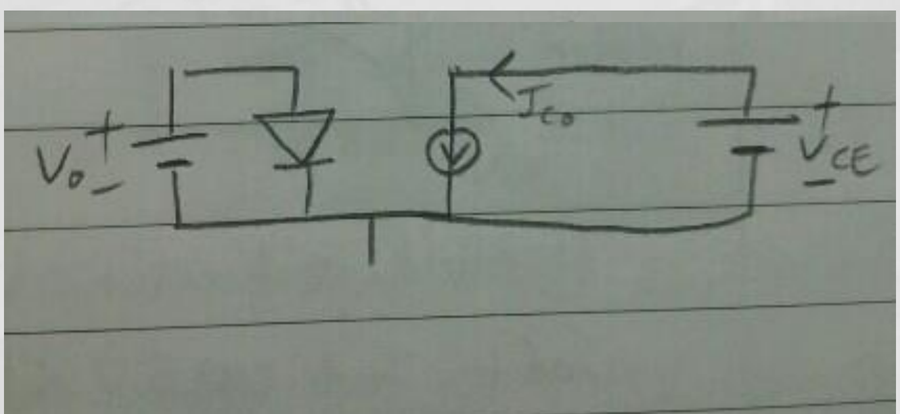
Lecture 17



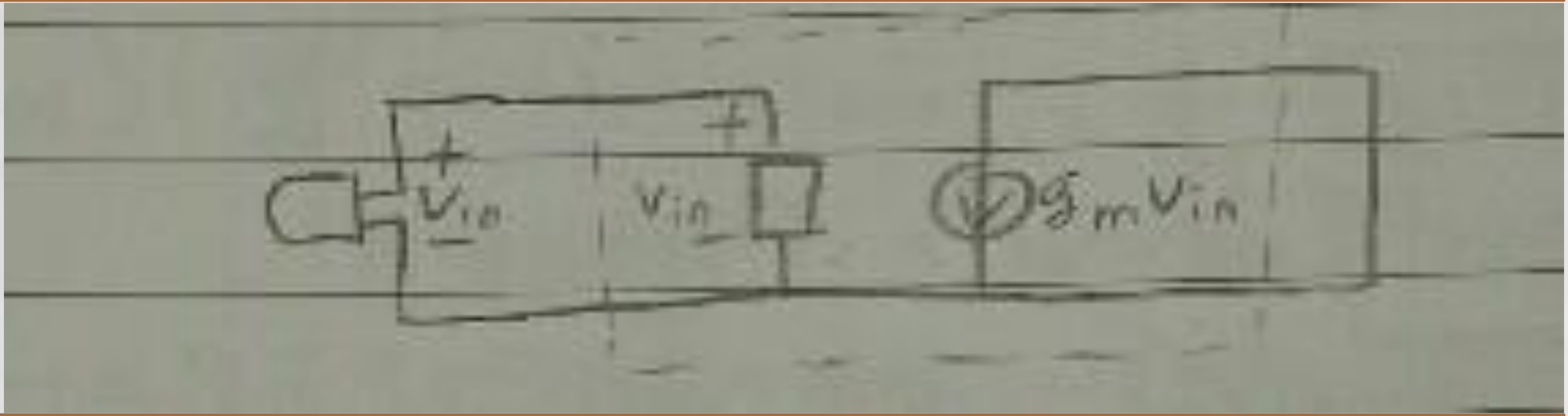


+

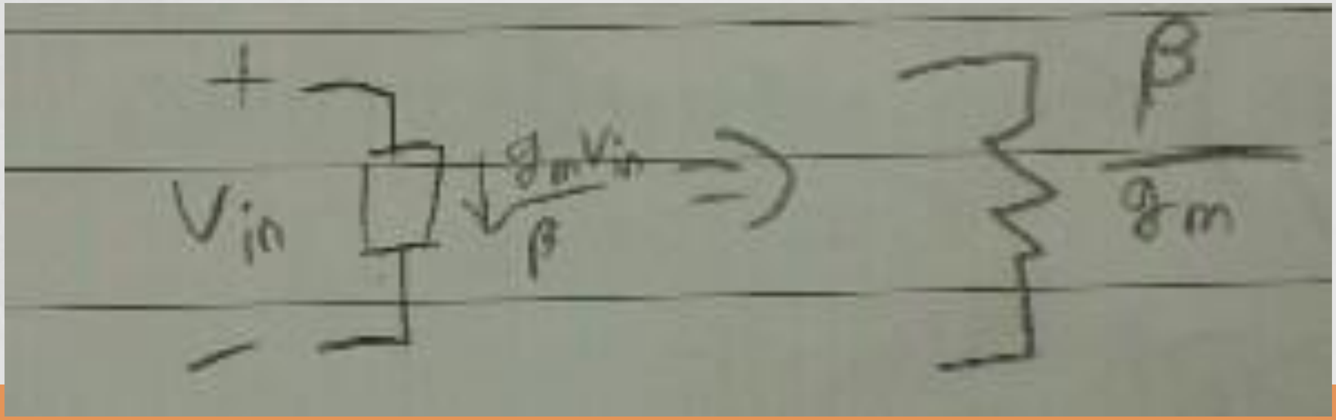
?

*Small-Signal Model 2

·First, we can expect Small-signal Model like below picture.

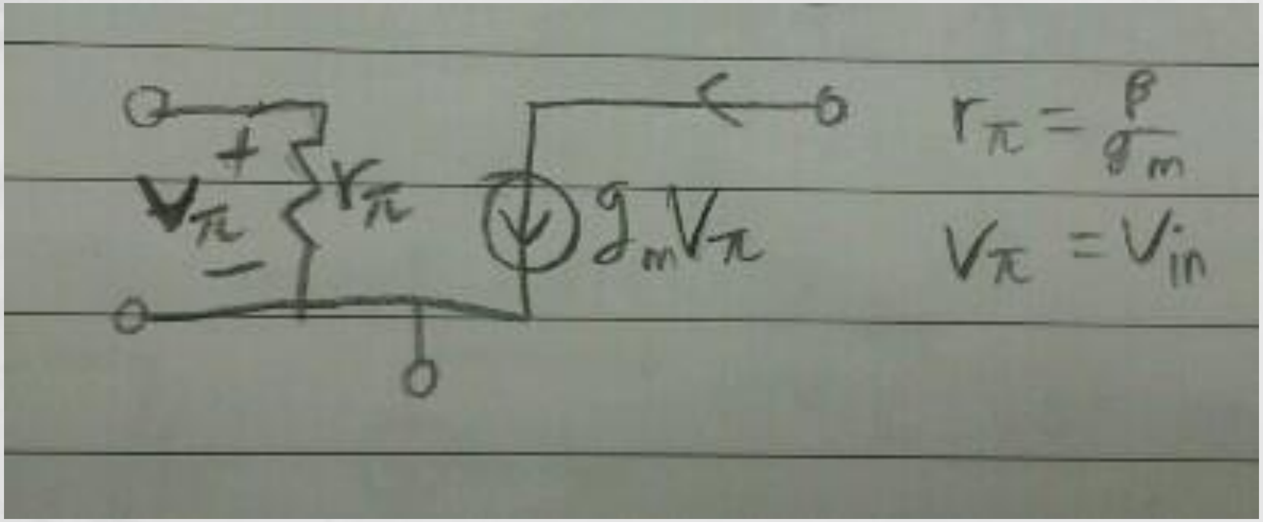


·Second, we expect rectangle device for I_B.



*Small-Signal Model 3

·Finally, we can draw Small-Signal Model!



*Small-Signal Model(Note)

·To find small-signal parameters, we must first calculate the bias conditions.

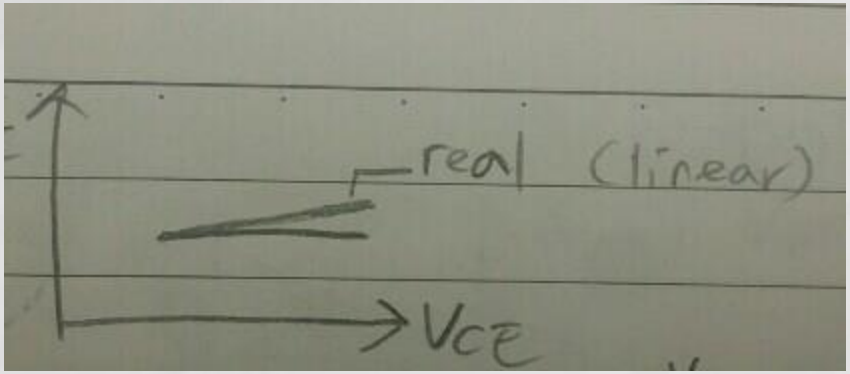
·In small-signal operation, batteries are replaced with a short circuit.

·Notation
Large-signal quantities : uppercase
-$V_{in}, I_C, V_{BE}, V_{CE}$ …

Small-signal quantities : lowercase
-$v_{in}, i_C, v_{BE}, v_{CE}$ …

*Early effect 1

·In real bipolar transistors, I_C is not constant according to V_{CE}.



WHY?

Because V_{CE} change depletion region of C-B
=>concentration of electrons is more sharply decrease
=>Current increase!

*Early effect 2

$$I_S = \frac{AqD_n n_i^2}{N_B W_B}$$

$V_{CE} \uparrow \Rightarrow W_B \downarrow$
=>Diffusion current ↑

*$I_C = (I_S exp\frac{V_{BE}}{V_T})(1 + \frac{V_{CE}}{V_A})$ in Large-signal
** V_A=early voltage

*Official method of Small-Signal model derivation

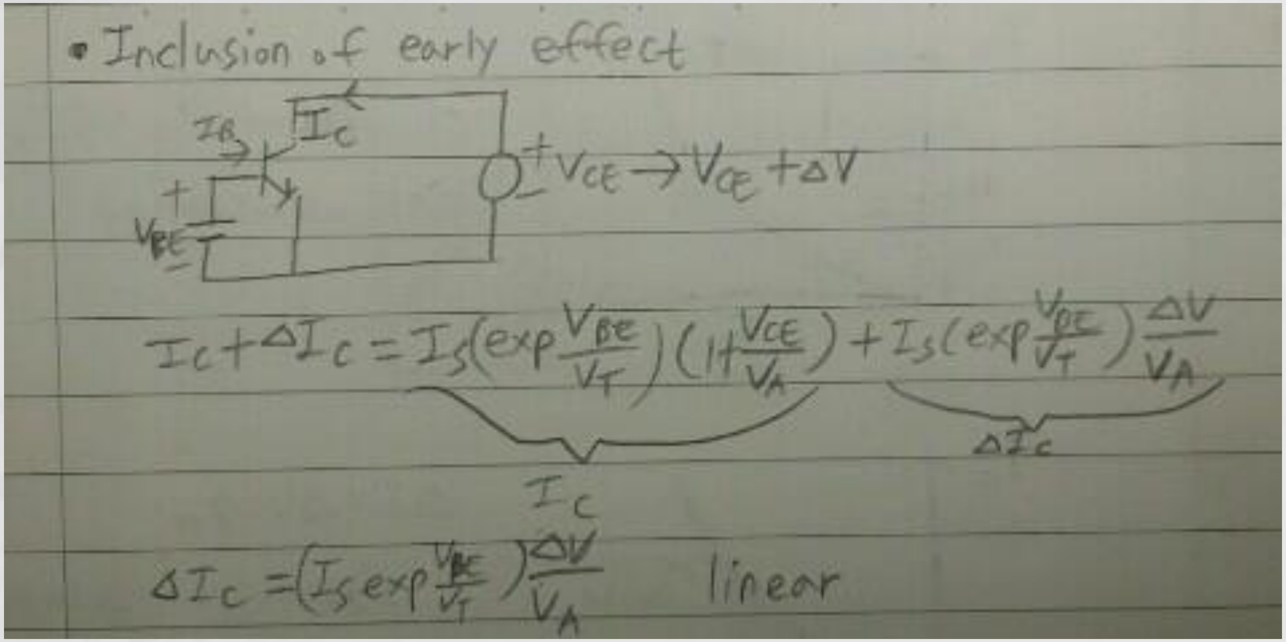
YouTube
Lecture 18

Step 1. Assume the transistor is biased at a certain operating point

Step 2. Apply a voltage change between two terminals and measure the resulting current changes

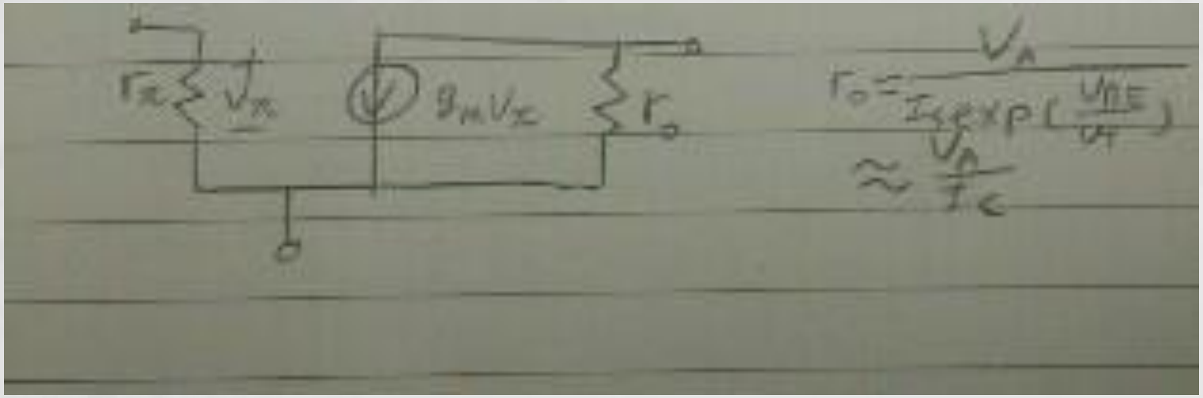
Step 3. Model the current changes by proper electric devices

*Early effect in small-signal model 1



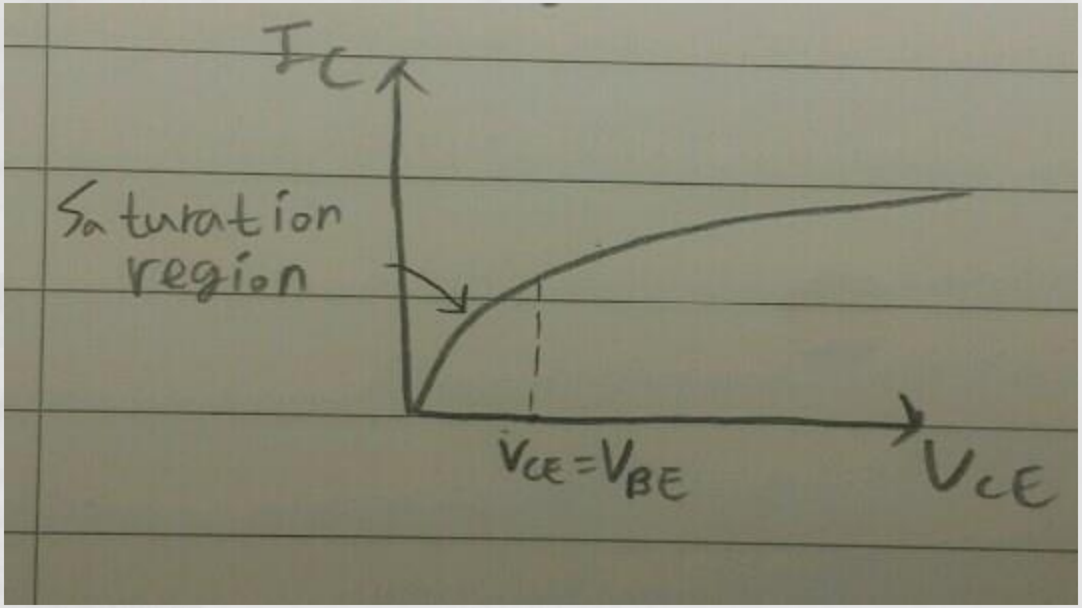
Using resistance for $\Delta I_C, \Delta V$.

*Early effect in small-signal model 2



*Saturation region

·If $V_{CE} < V_{BE}$, we can't get desired value of anything because C-B is forward Bias.



Thank you