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# Lesson 17

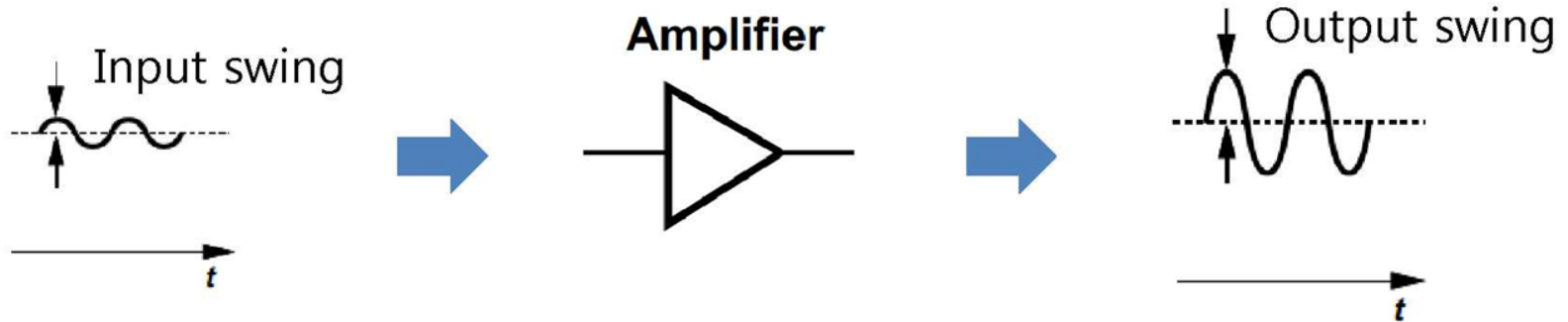
# Common-Emitter Stage

2009142222 Woo-chan Song

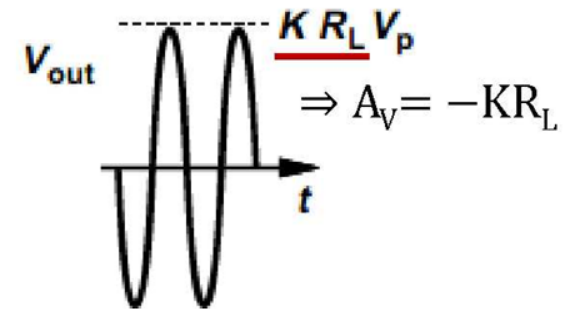
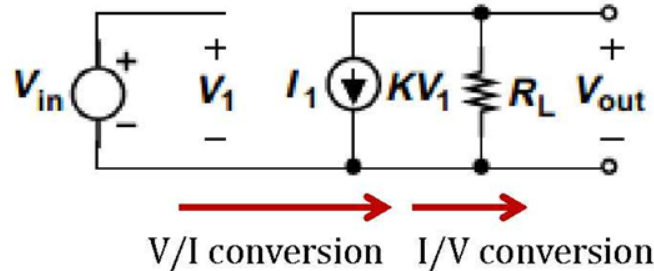
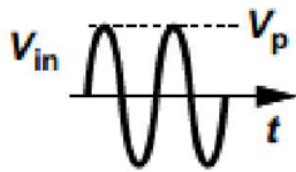
- Youtube: Lec. 19; from 28 min to end, Lec. 20
  - Textbook: 5.3.1
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# Lesson 17: Common-Emitter Stage

## • Amplifier



$$\text{Voltage gain} = \frac{\text{Output swing}}{\text{Input swing}} = A_V$$

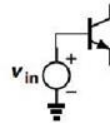


# Lesson 17: Common-Emitter Stage

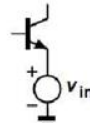
## • Common-Emitter Stage

### - Topology

Input cases  $\Rightarrow$



(a)



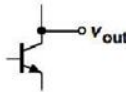
(b)



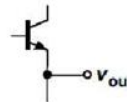
(c)

( $\because V_{in}$  does not affect the base or emitter voltages.)

Output cases  $\Rightarrow$



(d)



(e)

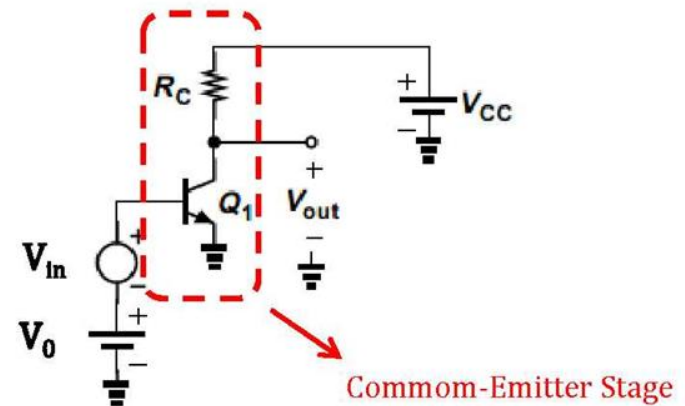
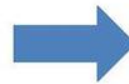
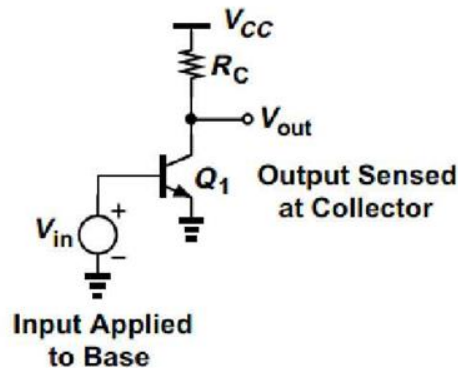


(f)

( $\because V_{out}$  is not a function of the collector current.)

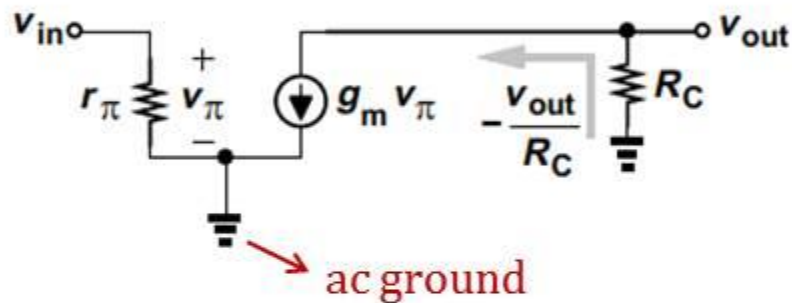
(b) + (e) (x) ( $\because V_{in} = V_{out} \Rightarrow$  No function)

### - Common-Emitter Topology



# Lesson 17: Common-Emitter Stage

- **Small-Signal Voltage Gain**  
(Assume  $V_A = \infty$ )



$$v_{\pi} = v_{in} \Rightarrow g_m * v_{\pi} = g_m * v_{in}$$

$$g_m * v_{in} = -\frac{v_{out}}{R_C} \Rightarrow \frac{v_{out}}{v_{in}} = -g_m * R_C = A_V$$

$$A_V = -g_m * (\text{total resistance tied between the collector and ac ground})$$

※  $A_V$  in active region

$$|A_V| = g_m R_C = \frac{I_C R_C}{V_T}$$

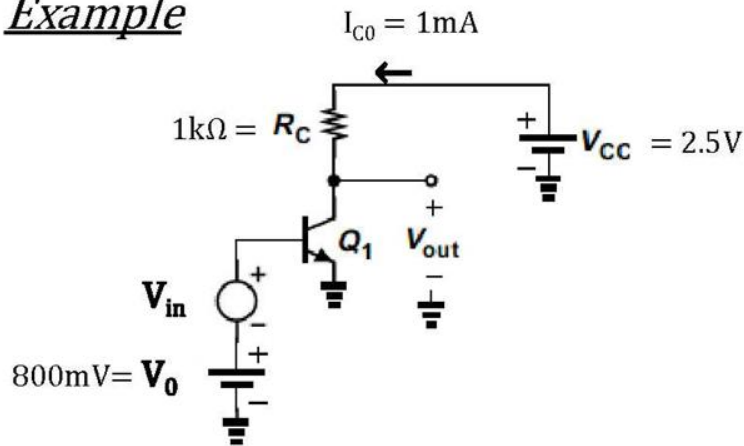
$$\Rightarrow |A_V| < \frac{V_{CC}}{V_T} \quad (\because V_{RC} < V_{CC})$$

$$\Rightarrow |A_V| < \frac{V_{CC} - V_{BE}}{V_T} \quad (\because V_{BE} < V_{CC})$$

# Lesson 17: Common-Emitter Stage

## • Small-Signal Voltage Gain (Assume $V_A = \infty$ )

### Example



$$g_m = \frac{1mA}{26mV} = \frac{1}{26\Omega}$$

$$A_V = -g_m * R_C = -1k\Omega * \frac{1}{26\Omega} \approx -38$$

$$(V_{CE} = V_{CC} - V_{RC} = 2.5V - 1V = 1.5V > V_{BE})$$

### ※ Double $A_V$

$$A_V = -g_m * R_C$$

$$i) R_C \Rightarrow 2R_C$$

$$R_C = 2k\Omega$$

$$V_{CE} = 2.5V - 2V = 0.5V < V_{BE} \Rightarrow \text{Saturation}$$

$$ii) g_m \Rightarrow 2g_m$$

$$g_m = -\frac{I_C}{V_T} * R_C$$

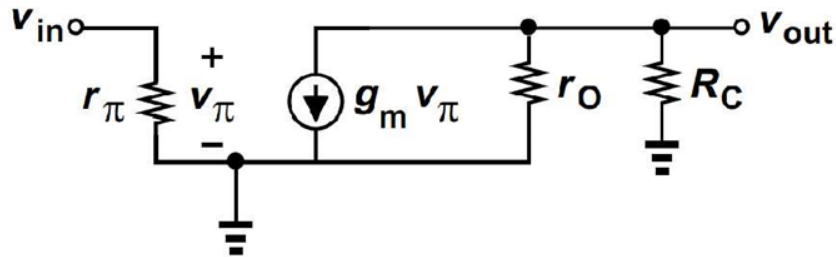
$$\text{Double } I_C \Rightarrow I_C * R_C \text{ doubles} \Rightarrow V_{CE} < V_{BE}$$

$$\Rightarrow \text{Saturation}$$

$$|A_V| < \frac{V_{CC} - V_{BE}}{V_T} = \frac{1700mV}{26mV} \approx 65.3$$

# Lesson 17: Common-Emitter Stage

- Inclusion of Early Effect



$$A_V = -g_m * (r_o \parallel R_C)$$

$$\text{※ } R_C \rightarrow \infty$$

$$A_V = -g_m * r_o$$

$$= -\frac{I_C}{V_T} * \frac{V_A}{I_C} = -\frac{V_A}{V_T} \Rightarrow \text{const.}$$

$g_m * r_o$  : intrinsic gain of the transistor

## Lesson 17: Common-Emitter Stage

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**Thank you**