EE210: Microelectronics-I

Lecture-14 :BJT Amplifier-part-3

https://youtu.be/i8a5BCAj8yM

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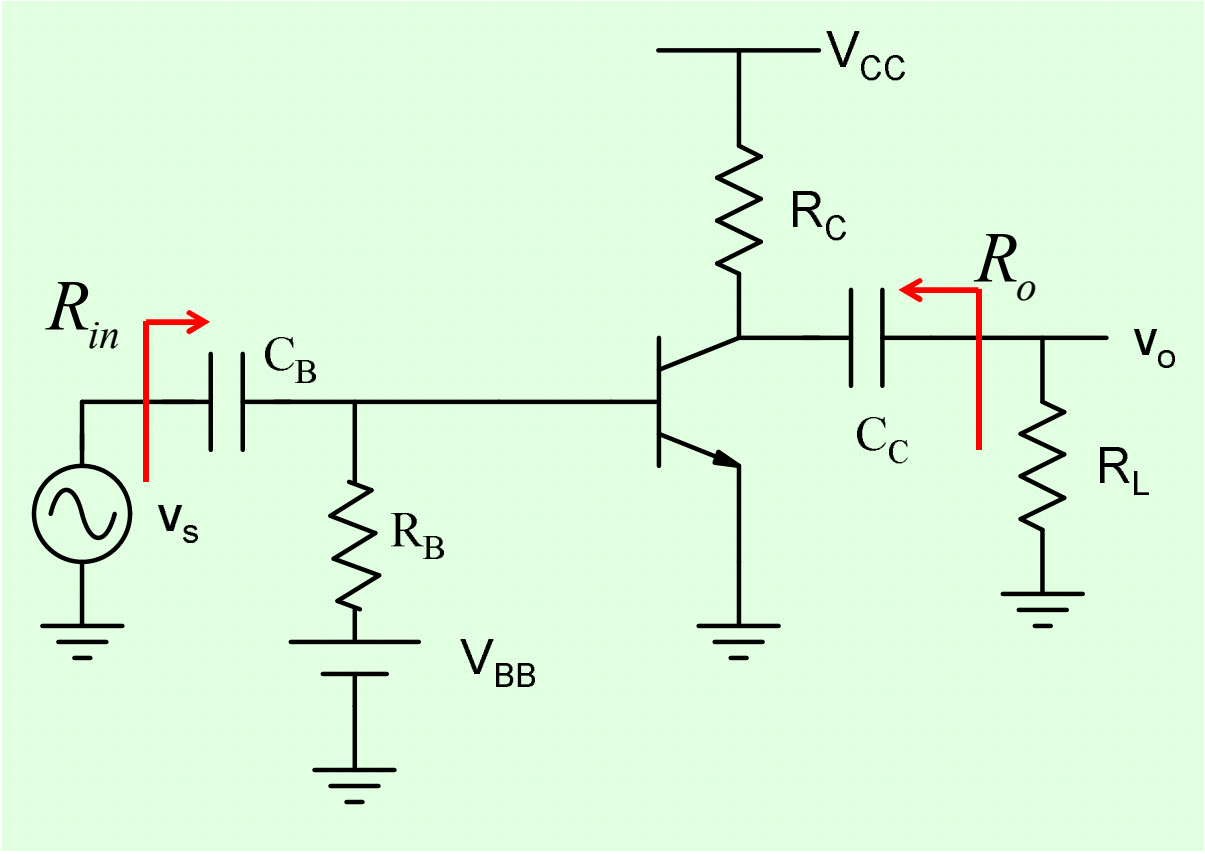
Basic Common Emitter Amplifier



A_V, A_{Vo}

R_{in}, R_o

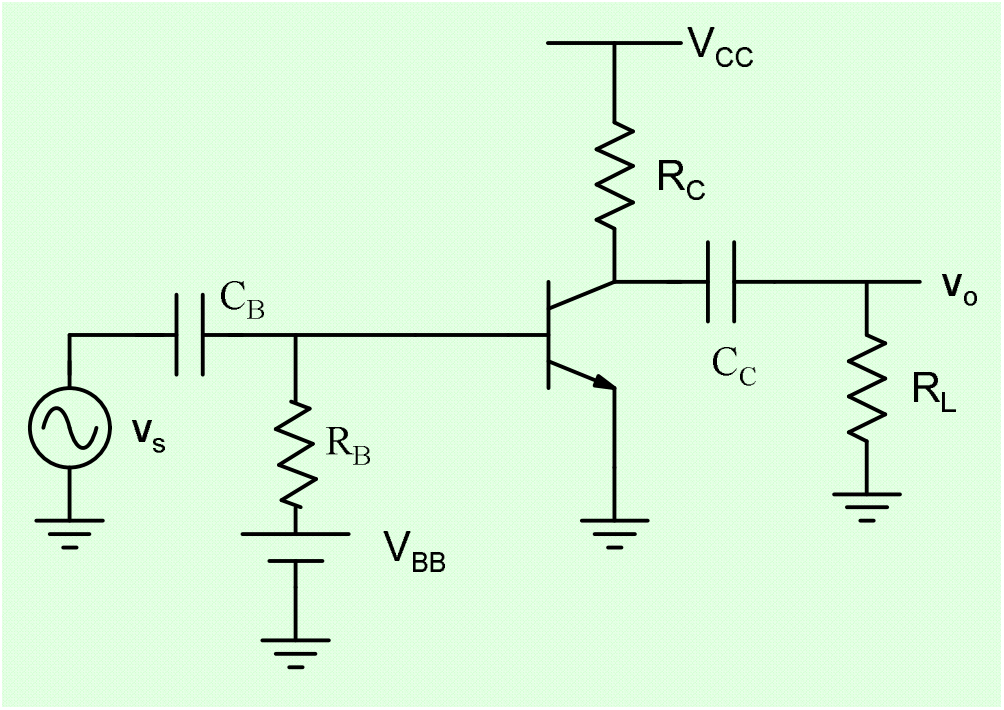
$v_o(\max.)$

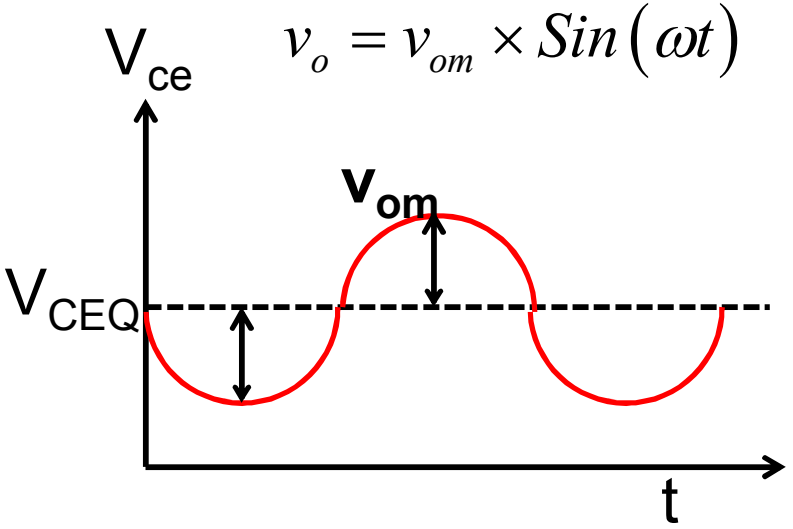
f_L, f_H

S_β

$$\frac{|A_{VO}| \times R_{in}}{R_O} \leq \beta$$

Output Voltage Swing





$$v_o = v_{om} \times Sin(\omega t)$$

$$V_{ce}(\max) = V_{CEQ} + v_{om}$$

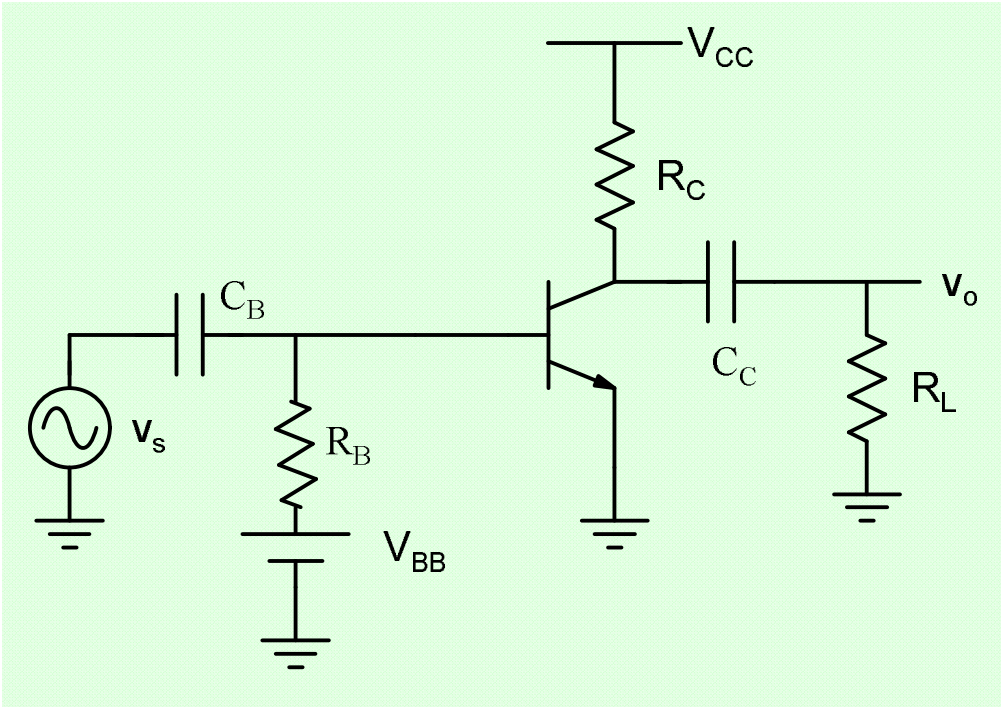
$$V_{ce}(\min) = V_{CEQ} - v_{om}$$

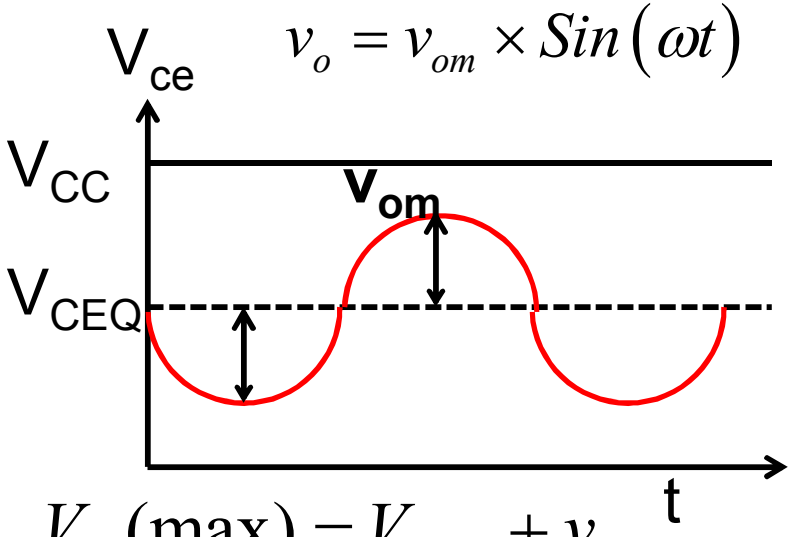
$$A_{VO} = -\left(\frac{V_{CC} - V_{CEQ}}{V_T}\right)$$

$$V_{ce}(\min) = V_{CEQ} - v_{om} > V_{CEsat}$$

$$v_{om} \leq V_{CEQ} - V_{CEsat}$$

Output Voltage Swing





$$v_o = v_{om} \times Sin(\omega t)$$

$$V_{ce}(\max) = V_{CEQ} + v_{om}$$

$$V_{ce}(\min) = V_{CEQ} - v_{om}$$

$$V_{ce}(\min) = V_{CEQ} - v_{om} > V_{CEsat}$$

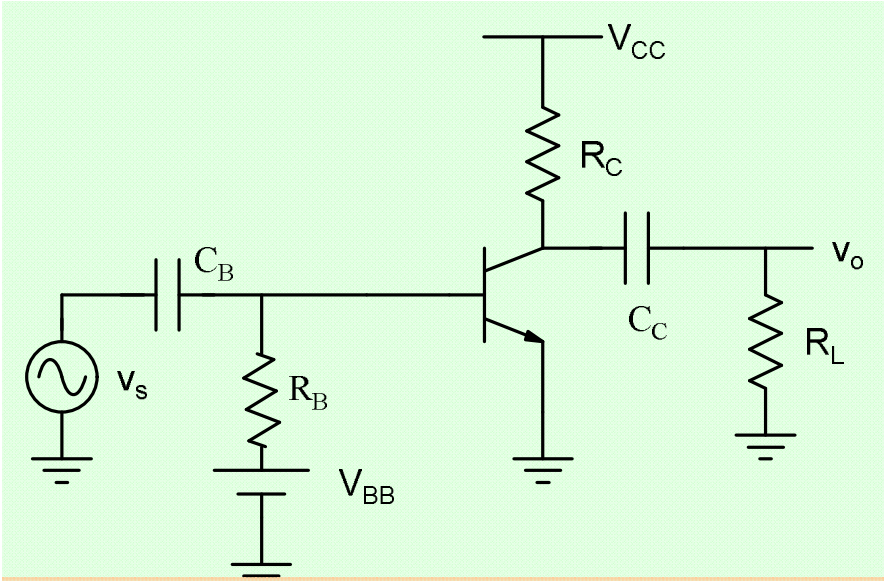
$$V_{ce}(\max) = V_{CEQ} + v_{om} < V_{CC}$$

$$v_{om} \le V_{CEQ} - V_{CEsat}$$

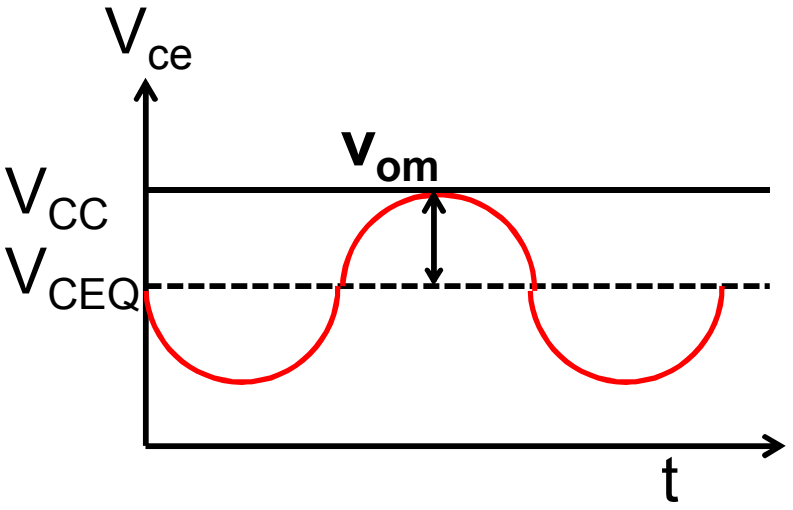
$$v_{om} \le V_{CC} - V_{CEQ}$$

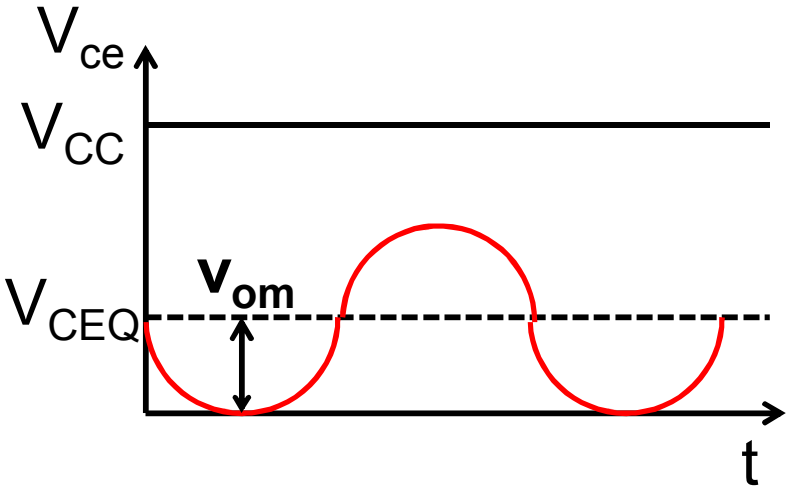
$$v_{om} = Min\left\{V_{CEQ} - V_{CEsat}; V_{CC} - V_{CEQ}\right\}$$

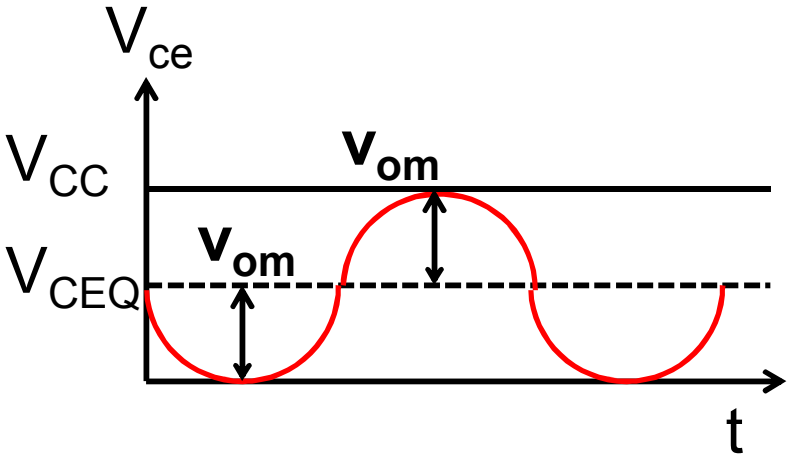
Design for Maximum Output Voltage Swing



$$v_{om} = Min\left\{V_{CEQ} - V_{CEsat}; V_{CC} - V_{CEQ}\right\}$$

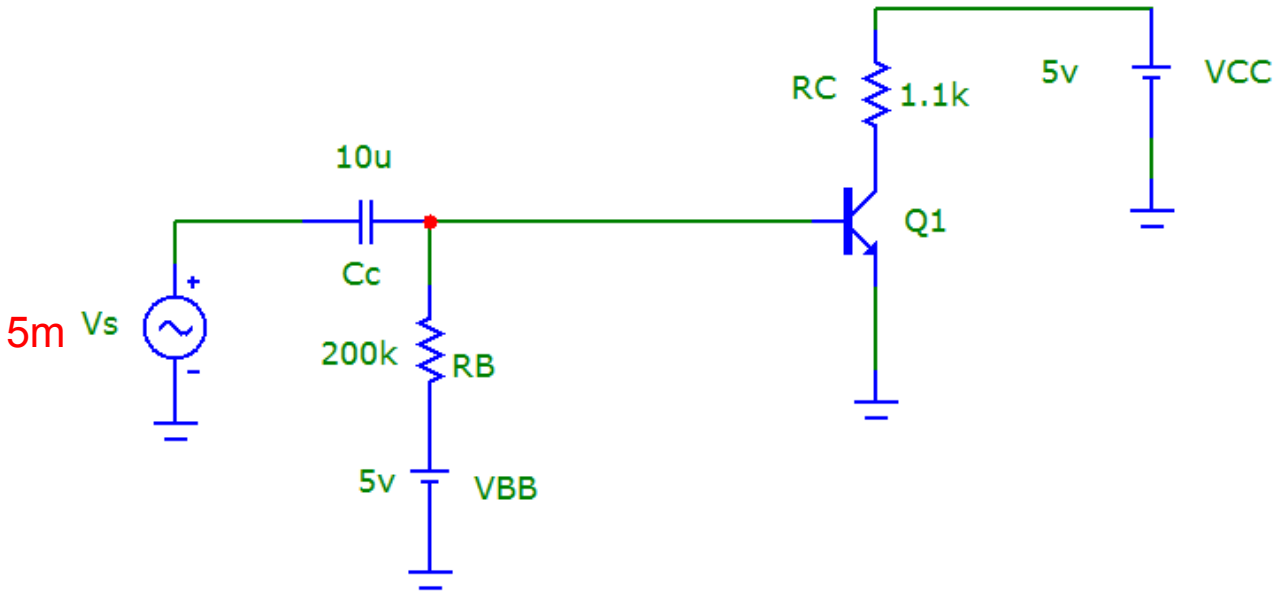


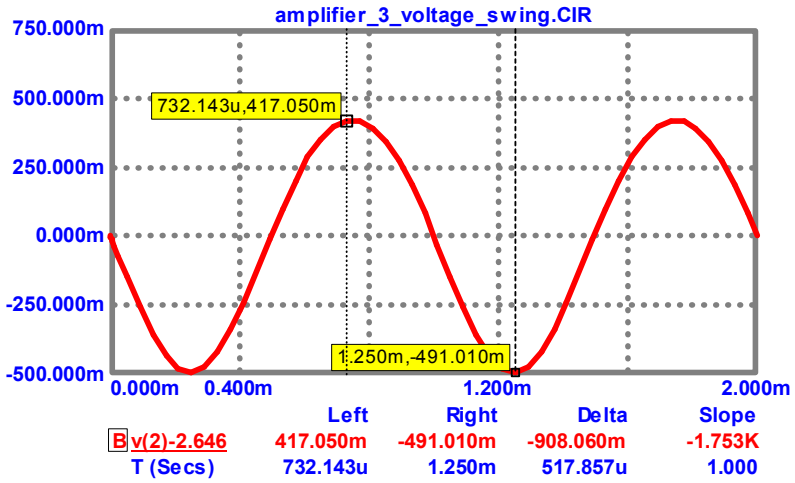




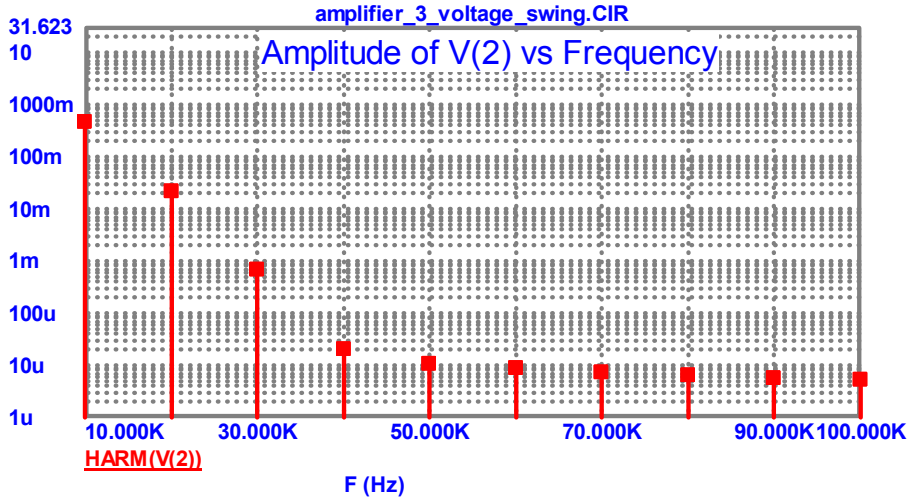
$$V_{CEQ} \sim \frac{V_{CC}}{2}$$

Simulation Results



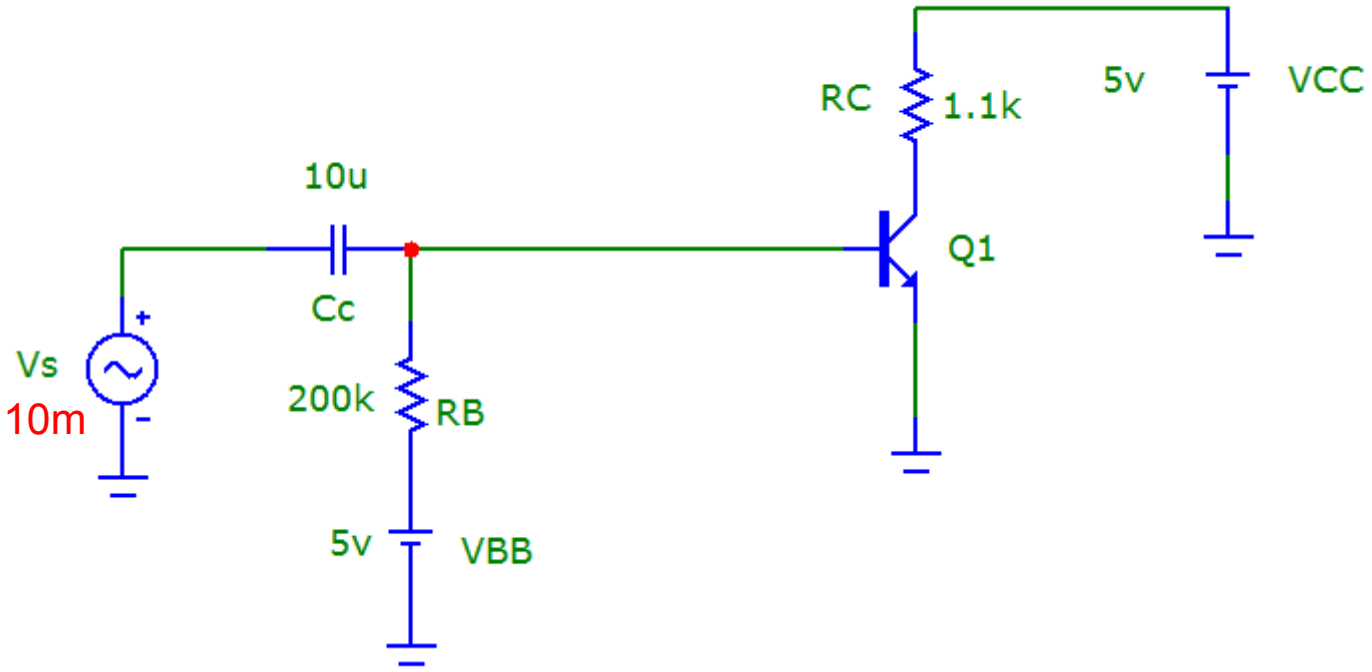


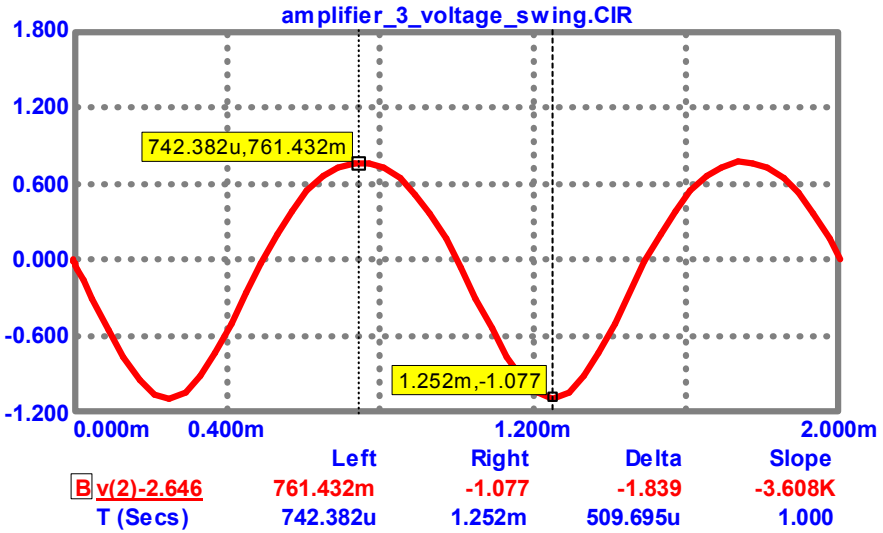
Vo (p-p) ~0.91V



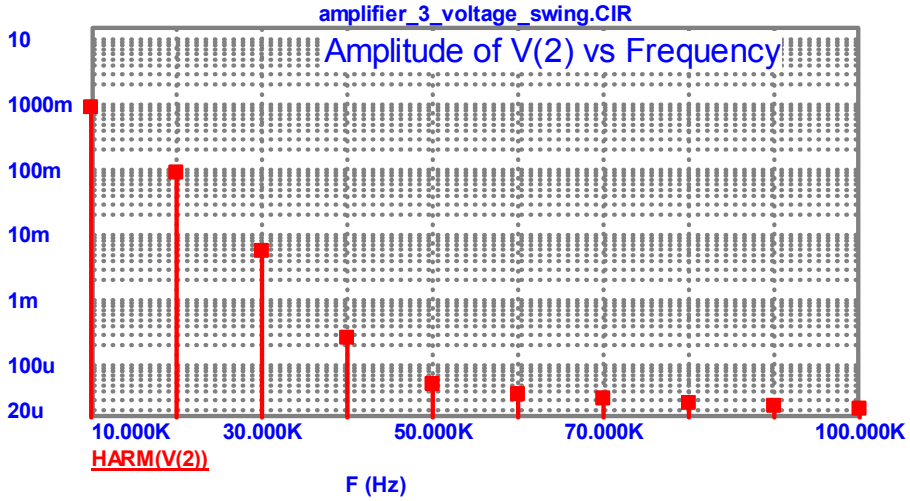
THD~4.8%

G-Number



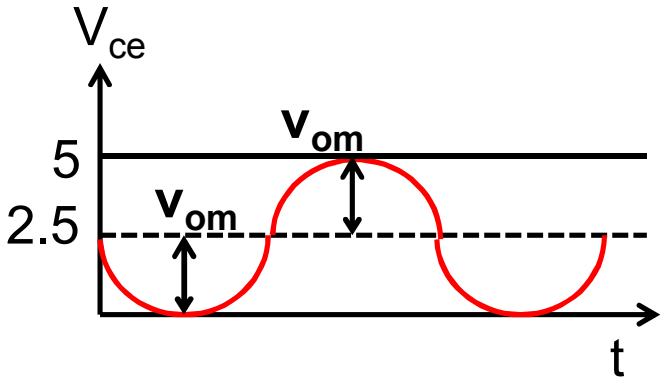


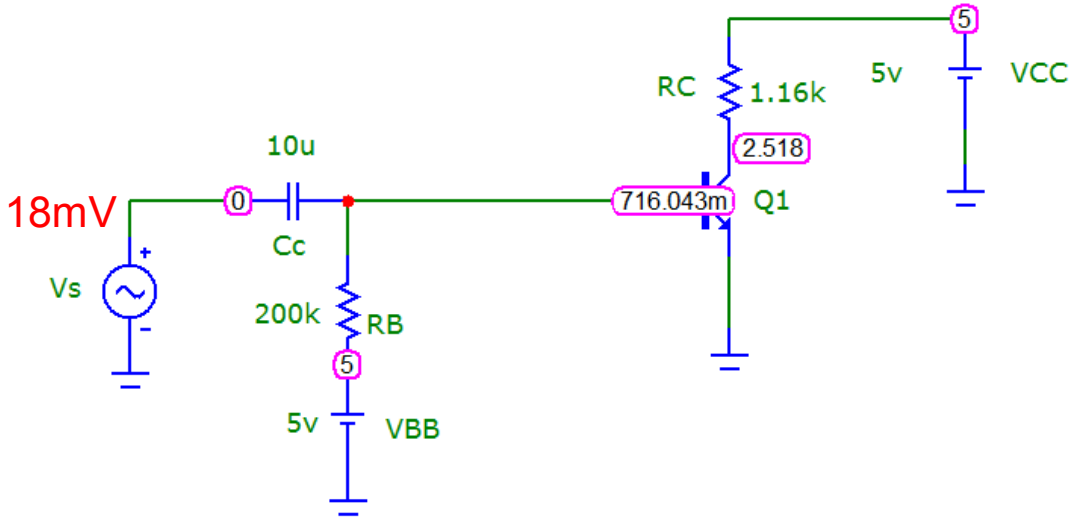
Vo (p-p) ~1.84V

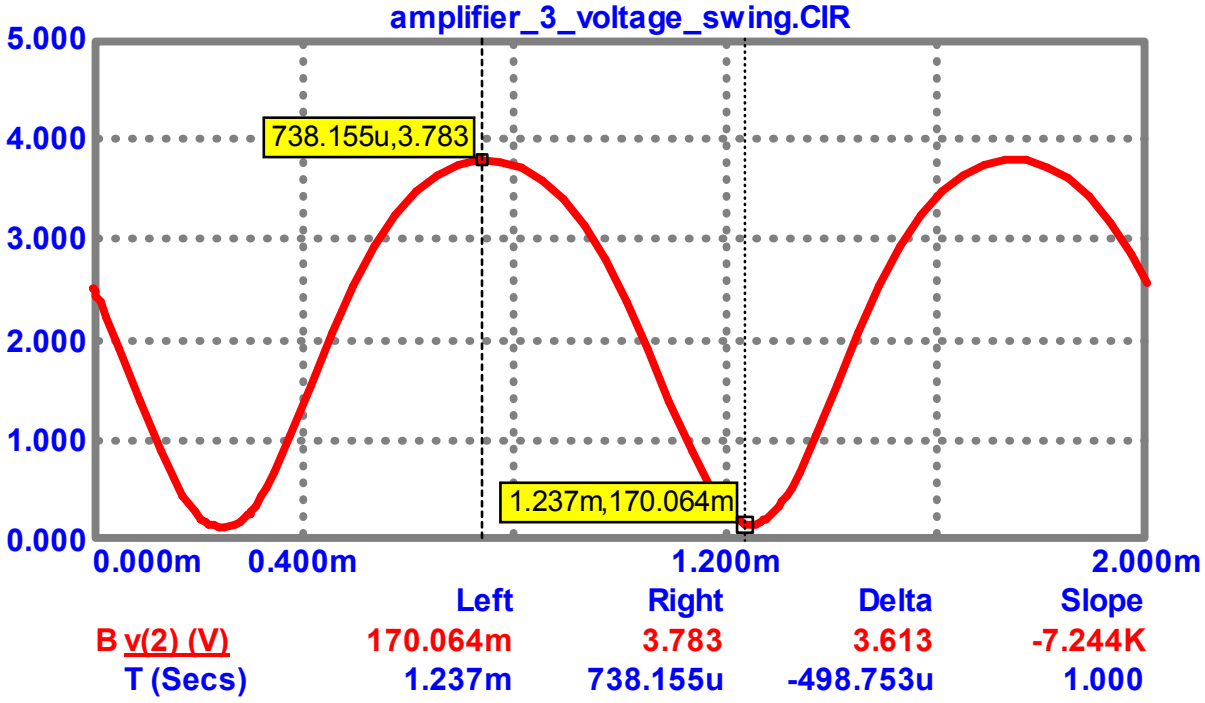


THD~9.6%

G-Number





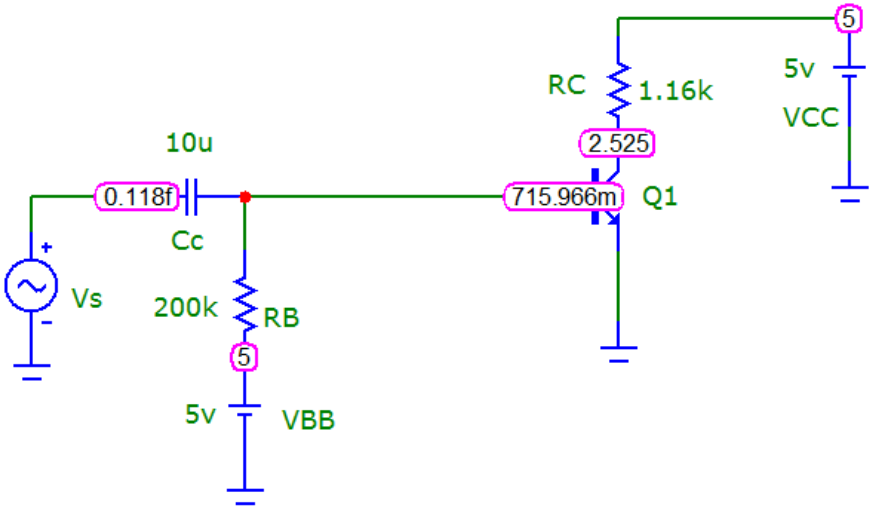


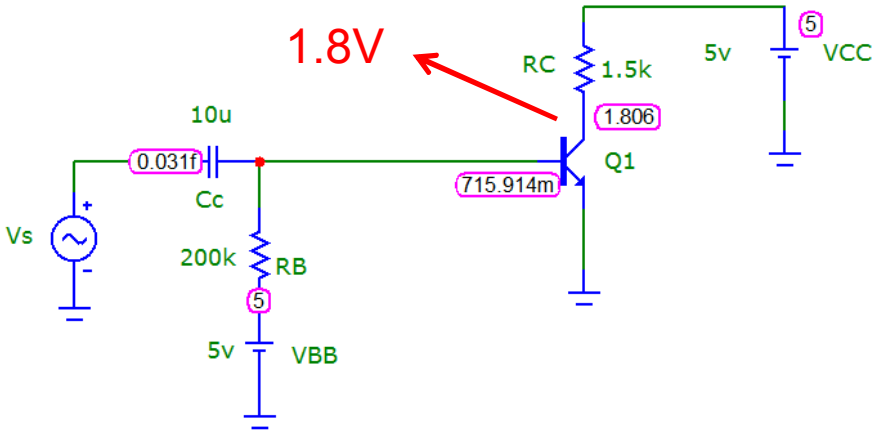
THD~16.9%

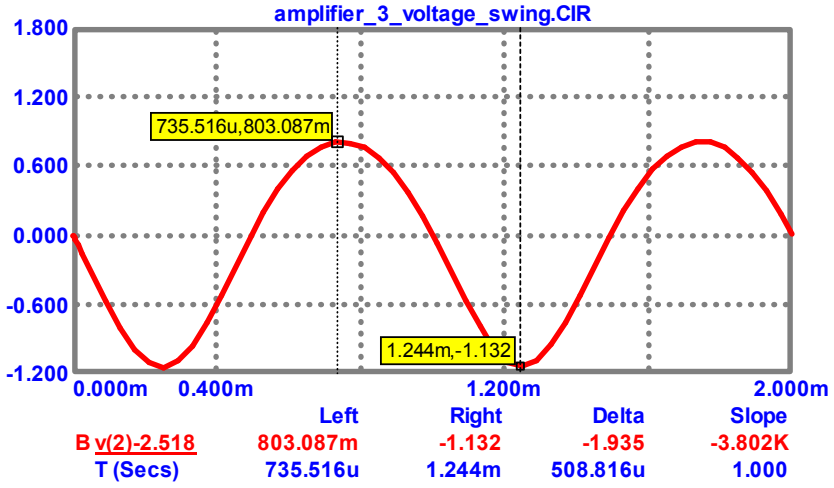
Vo (p-p) ~3.6V

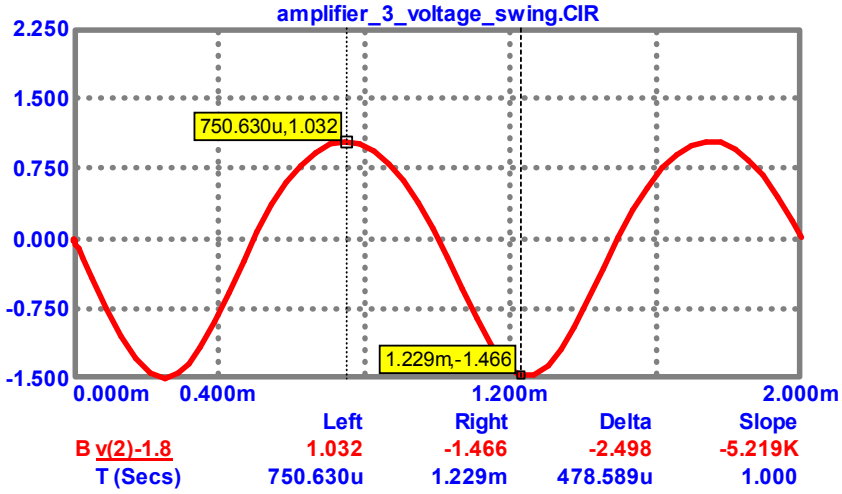
G-Number

Suppose I want the maximum output swing with THD < 10%







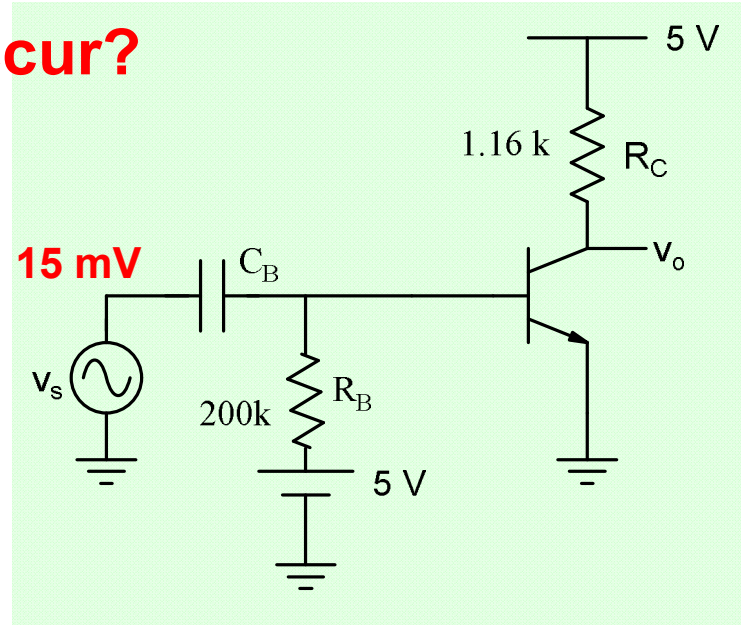


Vo (p-p) ~1.93V, THD ~9.6%

Vo (p-p) ~2.5V, THD ~9.6%

G-Number

Why does distortion occur?



$$I_c = I_{CQ} + i_c = I_S \times \exp\left(\frac{V_{BEQ} + v_{be}}{V_T}\right) \qquad i_c = I_{CQ} \times \left(\exp\left(\frac{v_{be}}{V_T}\right) - 1\right)$$

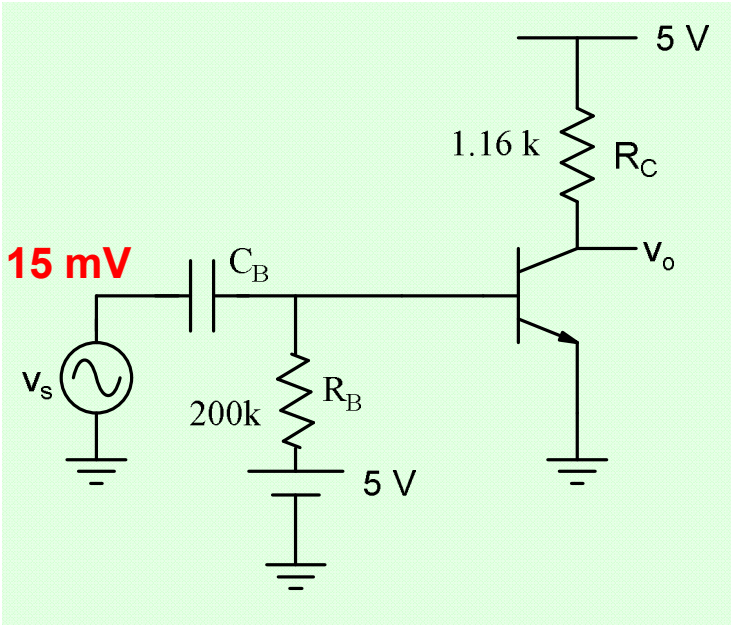
When vbe = 15mV, $i_c = 0.78 I_{CQ}$

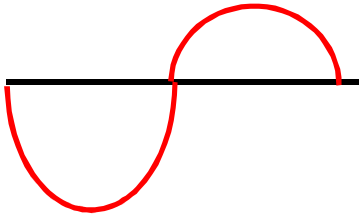
When vbe = -15mV, $i_c = -0.44 I_{CQ}$

When vbe = 2mV, $i_c = 0.08 I_{CQ}$

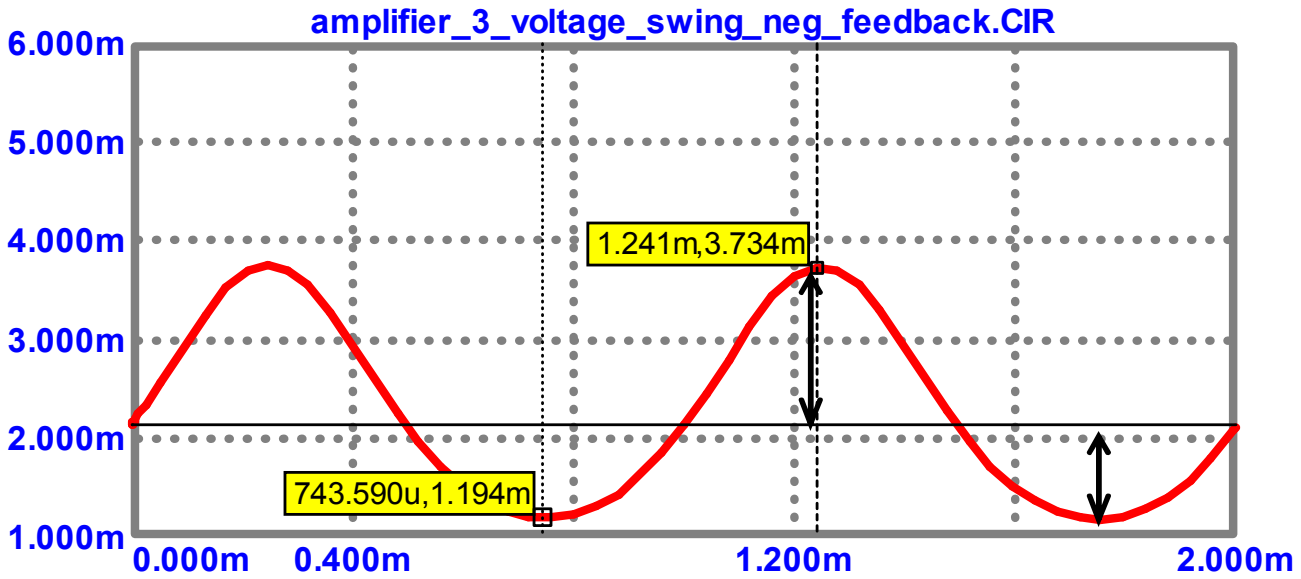
When vbe = -2mV, $i_c = -0.074 I_{CQ}$

$$i_c \cong g_m v_{be}$$



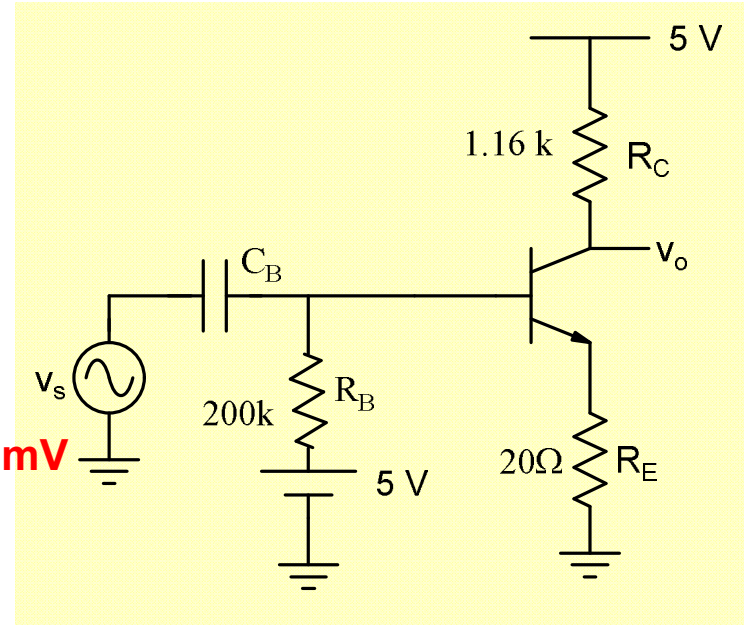


i_c

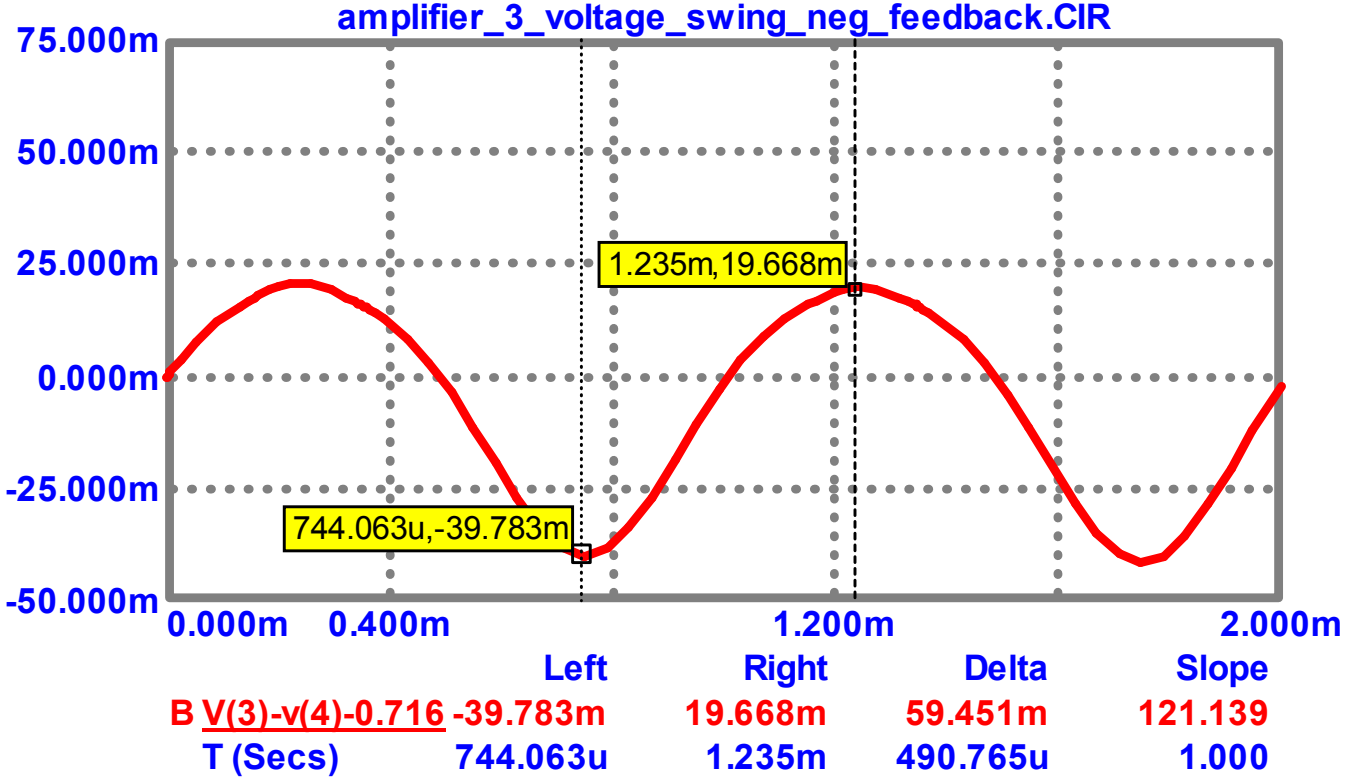


	Left	Right	Delta	Slope
B IC(Q1) (A)	1.194m	3.734m	2.539m	5.105
2.14m	2.140m	2.140m	0.000	0.000
T (Secs)	743.590u	1.241m	497.436u	1.000

G-Number

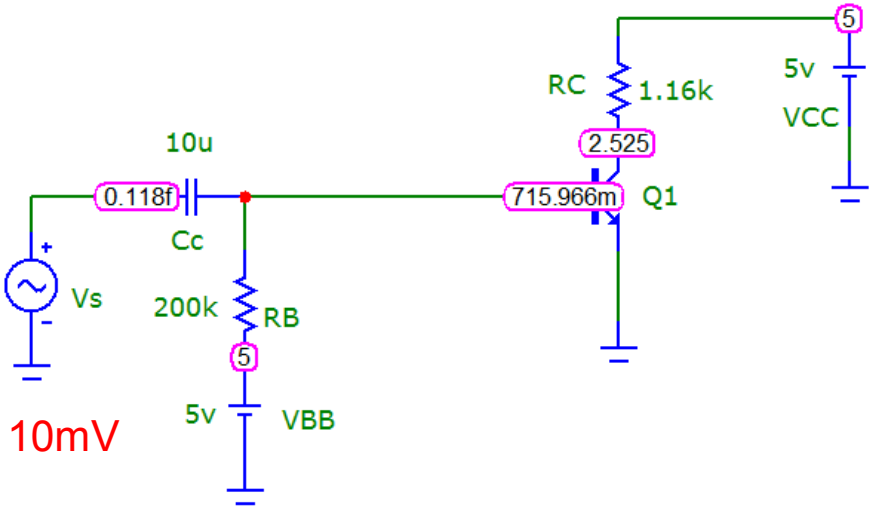


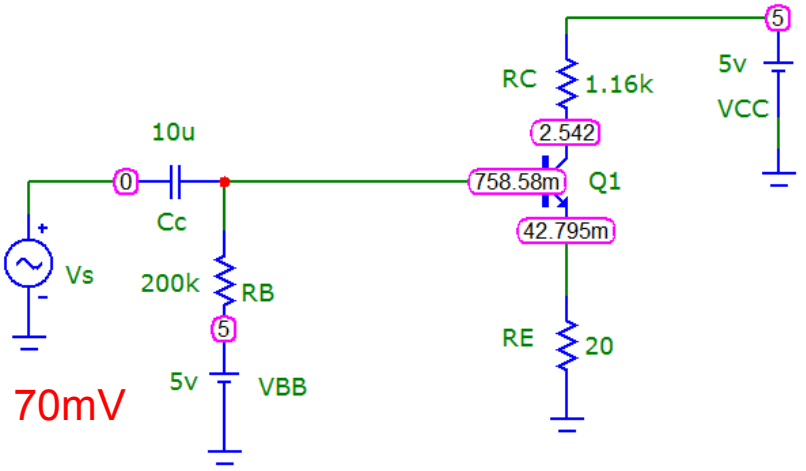
140mv p-p = 60 + 80

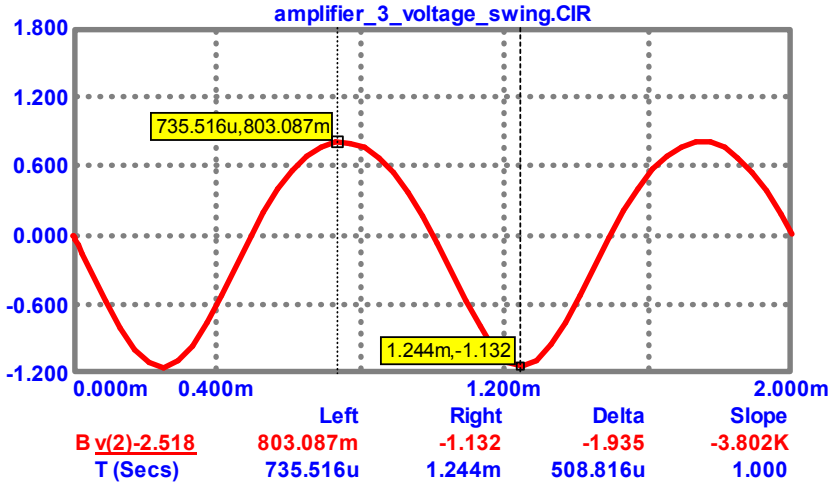


G-Number

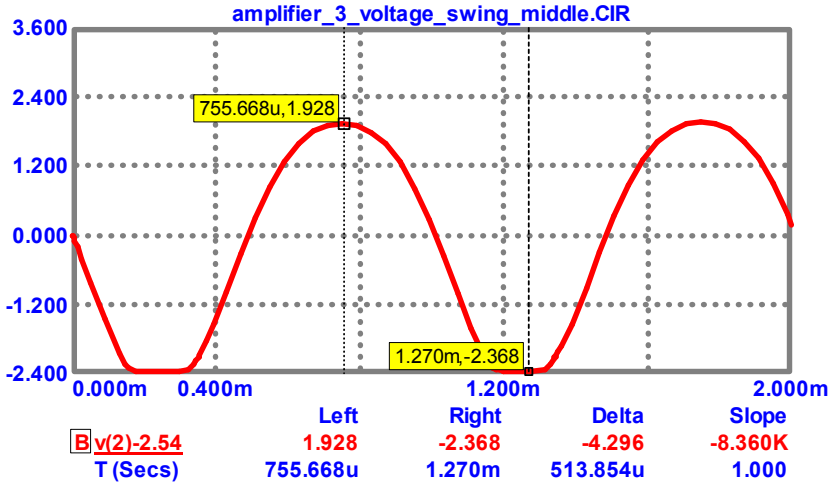
An emitter resistor helps to get improved swing



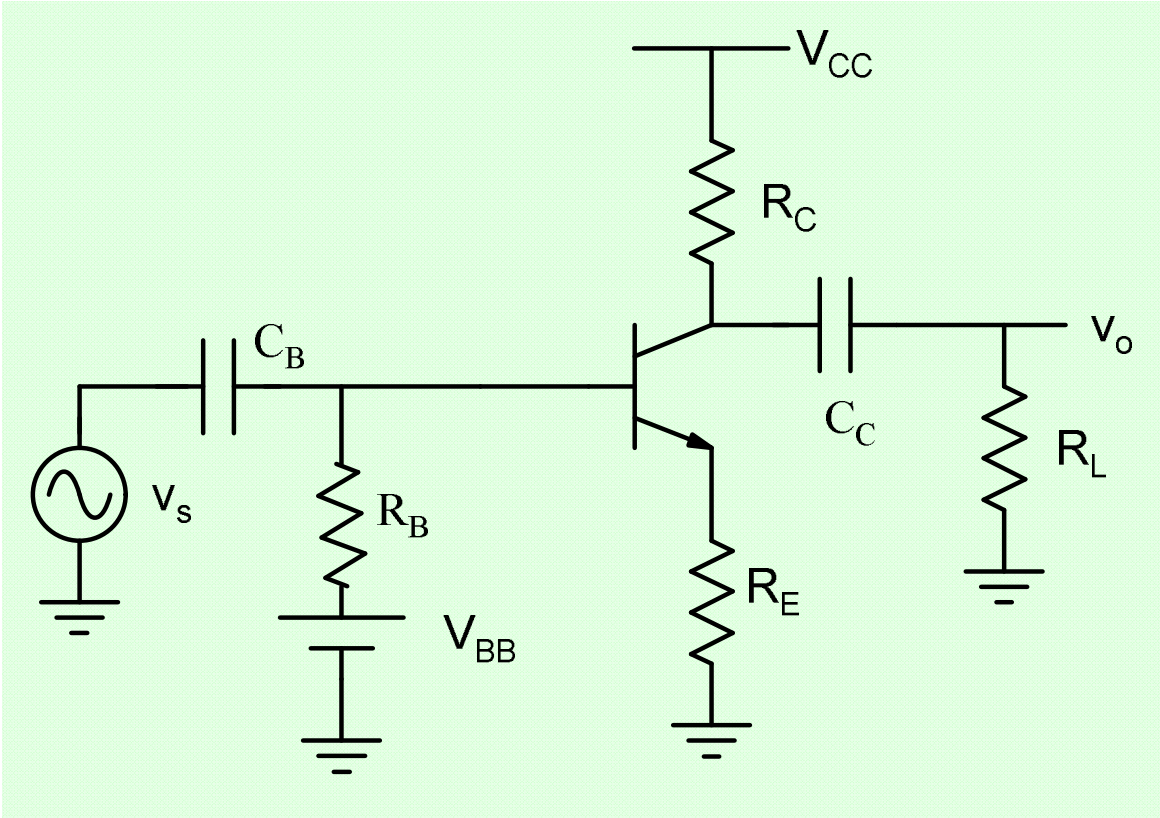




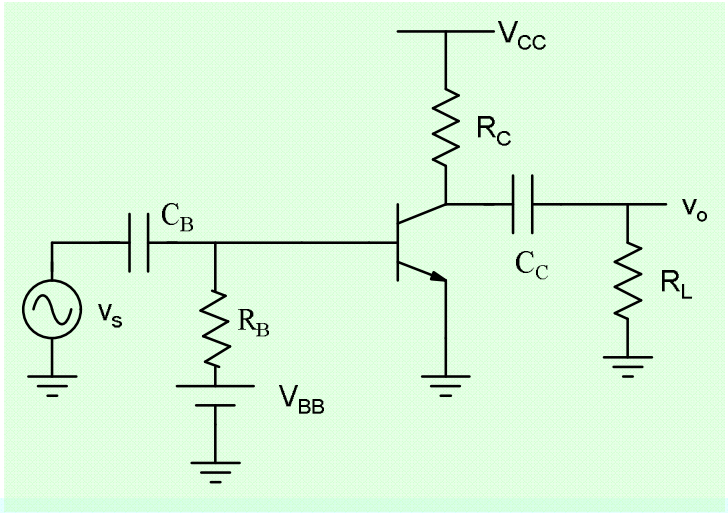
Vo (p-p) ~1.93V, THD ~9.6%

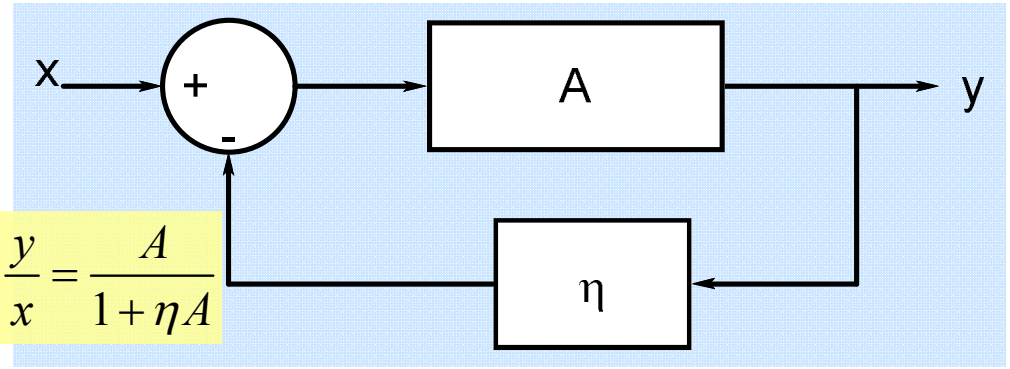


Vo (p-p) ~4.3V, THD ~9.6%

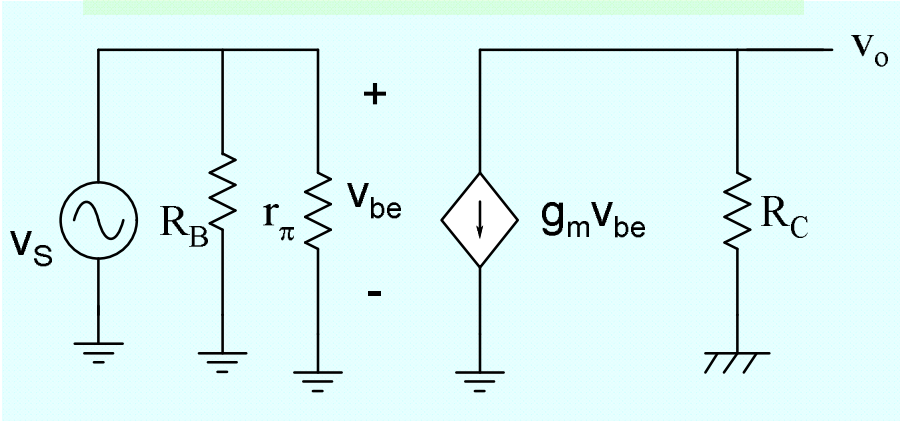


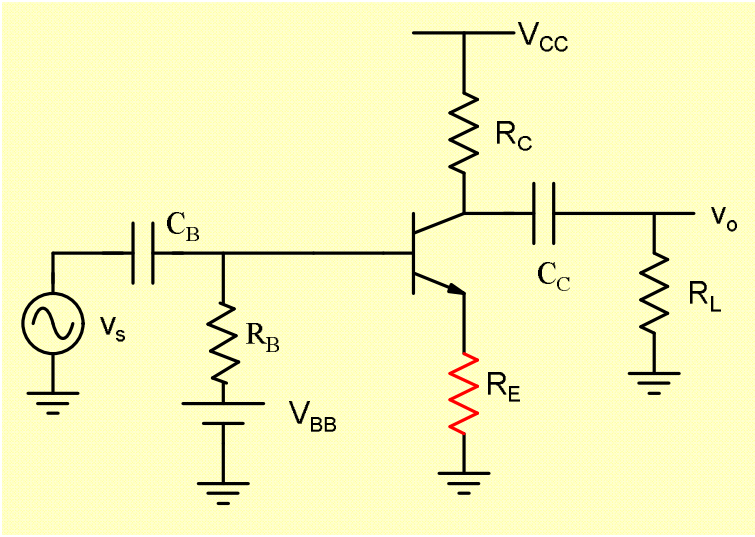
Emitter Resistance results in negative feedback which improves linearity and reduces distortion

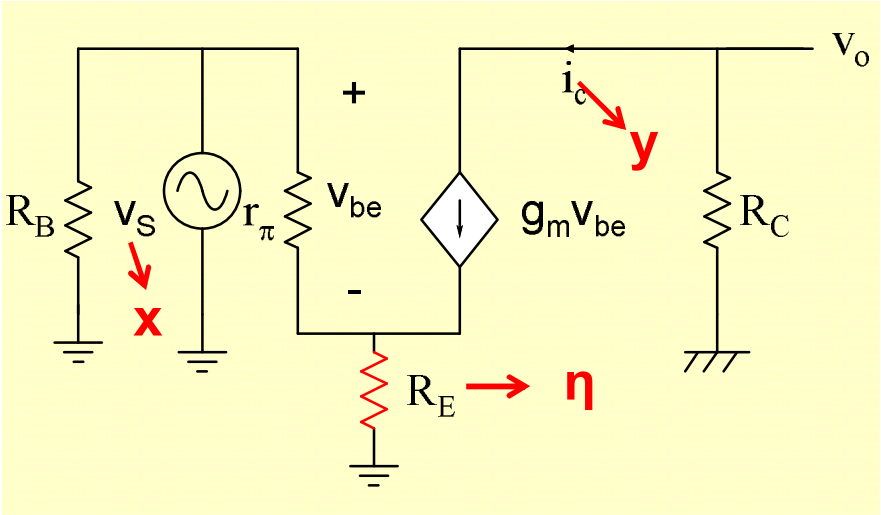


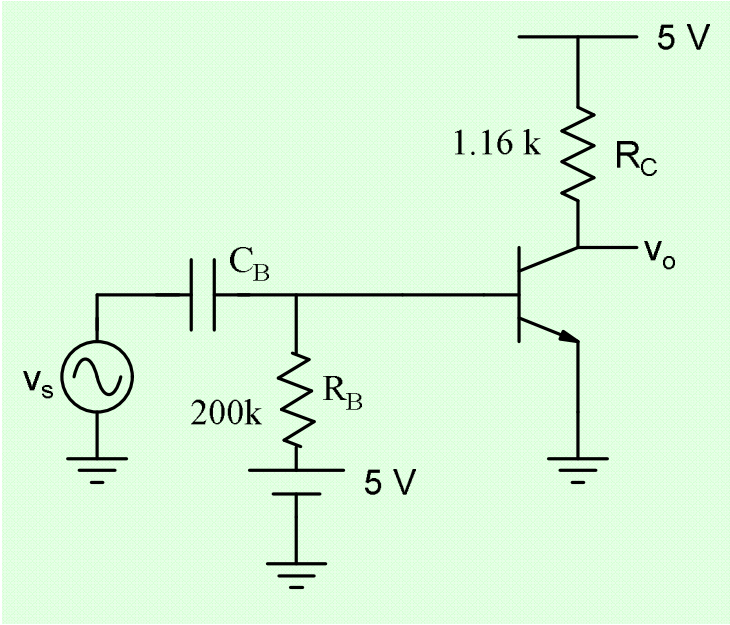


$$\frac{y}{x} = \frac{A}{1+\eta A}$$









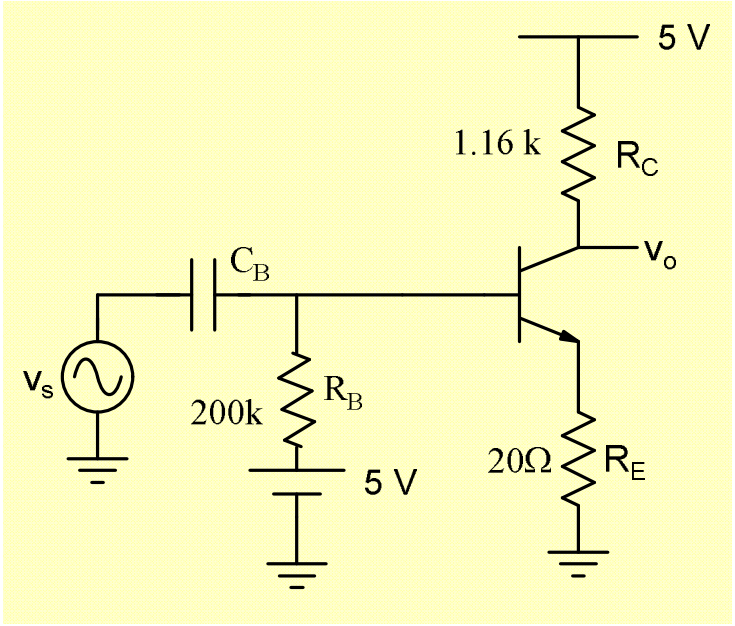
A_{Vo}=95.75

R_{in}=1.2 kΩ

R_O=1.16 kΩ

v_{opp}=1.93 V for THD~9.6%

$$\frac{|A_{VO}| \times R_{in}}{R_O} = 99$$



A_{Vo}= 35.7

R_{in}=3.18 kΩ

R_O=1.16 kΩ

v_{opp}=4.3 V for THD~9.6%

$$\frac{|A_{VO}| \times R_{in}}{R_O} = 97.86$$