Lecture 23

BJT

6.3 Frequency Response

Key Words:

Basic Concepts

High-Frequency BJT Model

Frequency Response of the CE Amplifier

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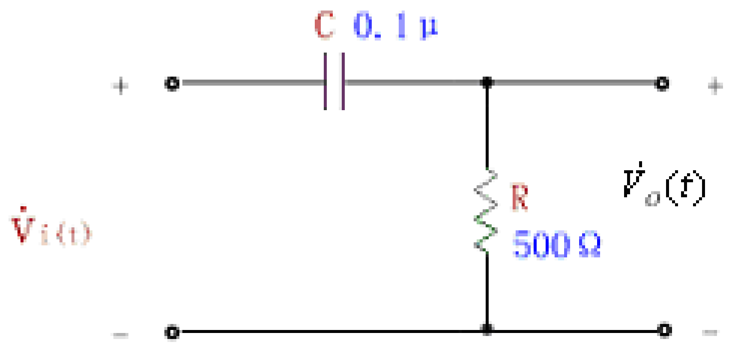
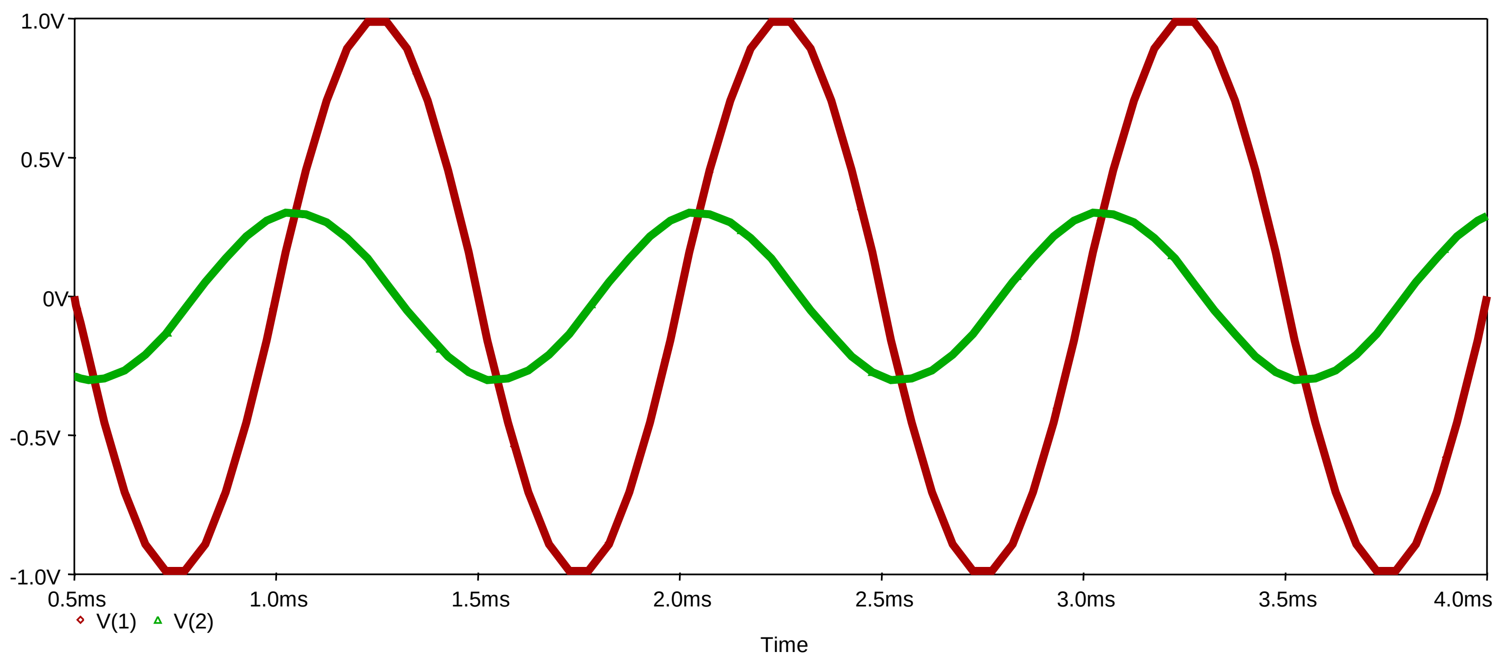
Basic Concepts





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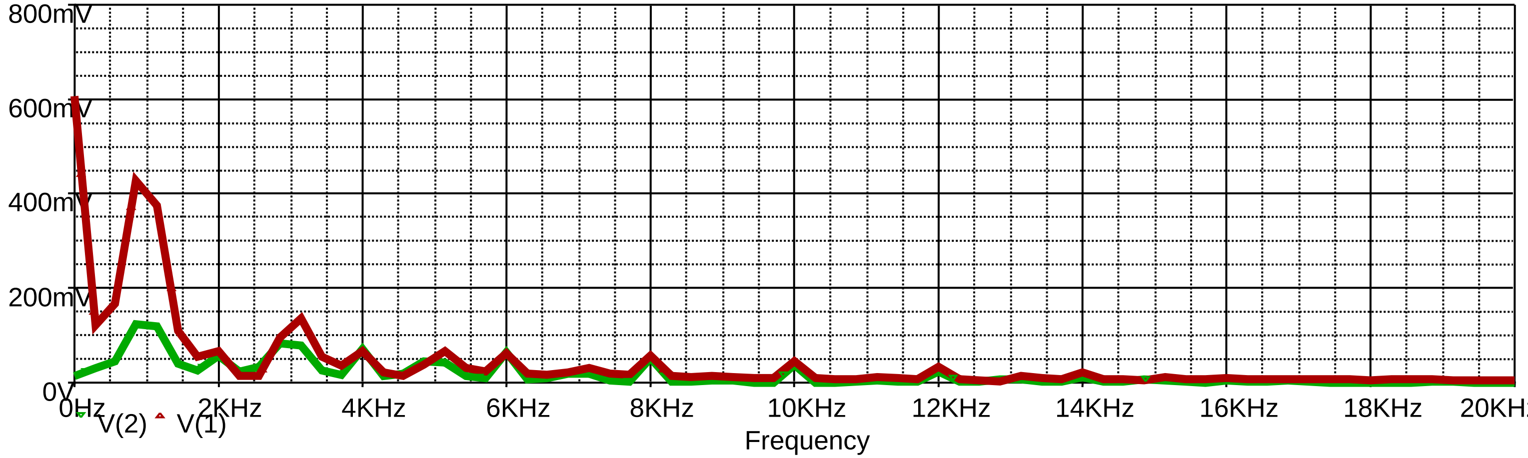
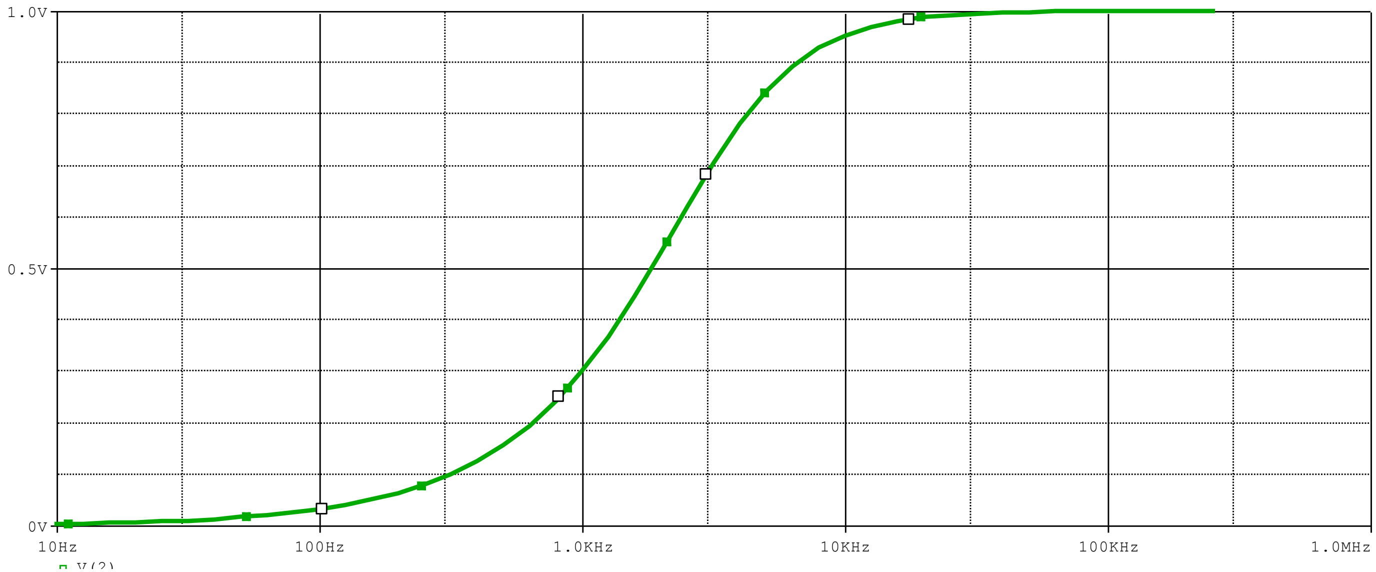
Basic Concepts





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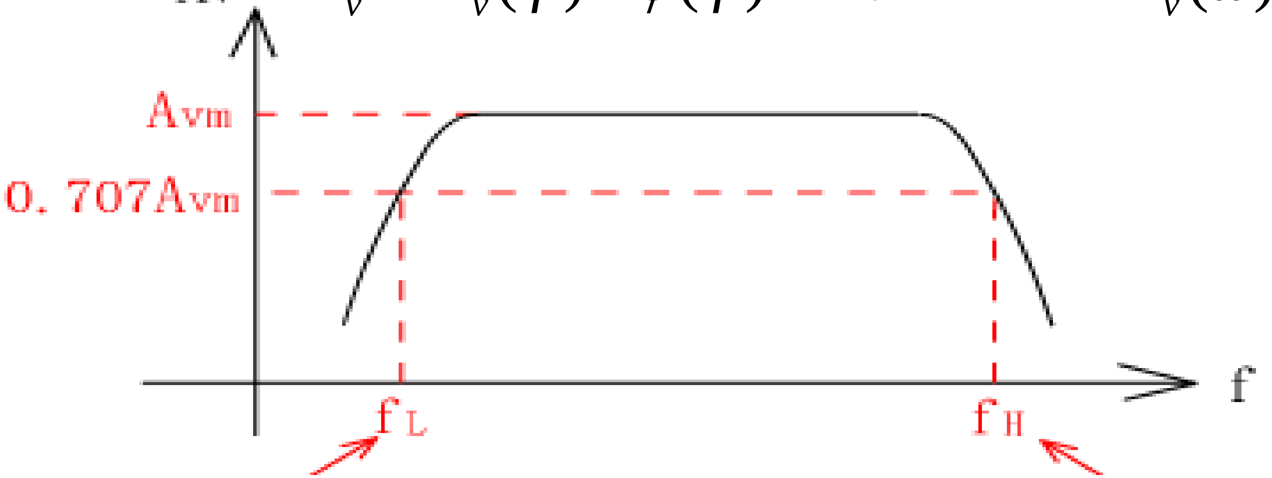
Basic Concepts

$$\dot{A}_v = A_v(f)\angle\varphi(f) \quad or \quad \dot{A} = A_v(\omega)\angle\varphi(\omega)$$



Lower cut off frequency Upper cut off frequency

The drops of voltage gain (output/input) is mainly due to:

1、Increasing reactance of C_s, C_c, C_e (at low *f*)

2、Parasitic capacitive elements of the network (at high *f*)

3、Dissappearance of changing current (for transformer coupled amp.)

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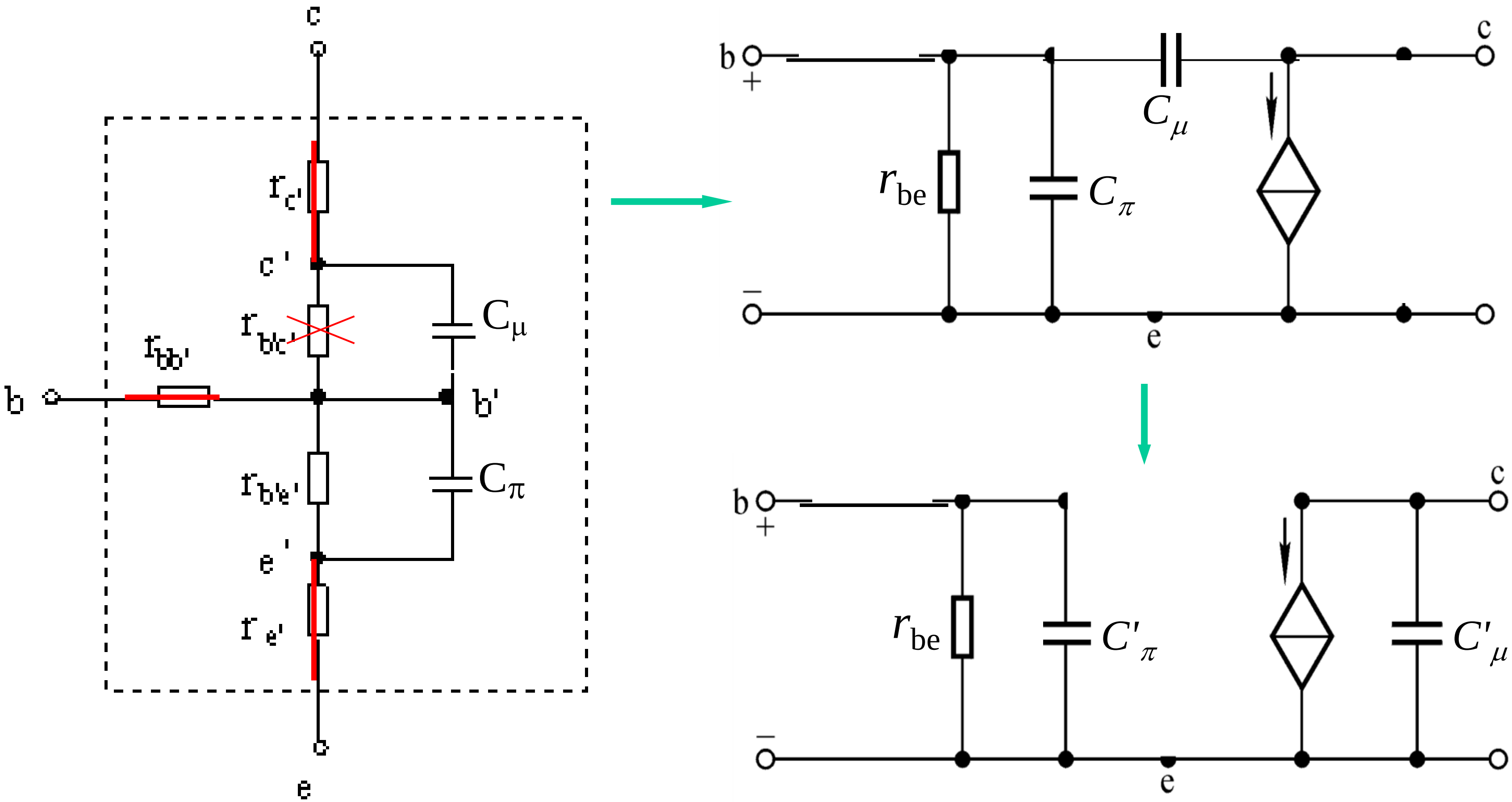
High-Frequency BJT Model

In BJTs, the PN junctions (EBJ and CBJ) also have capacitances associated with them



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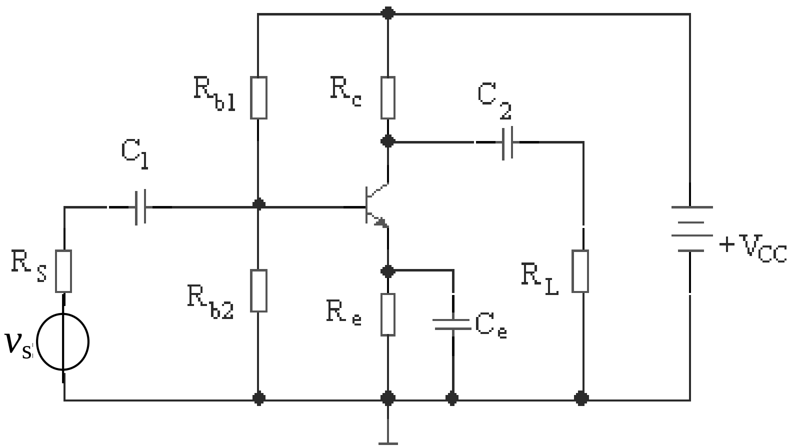
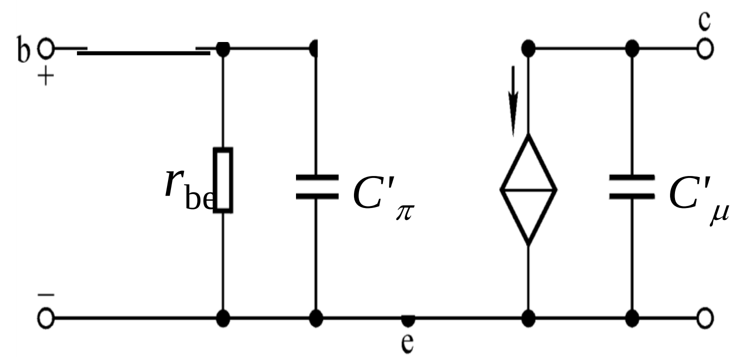
Frequency Response of the CE Amplifier





There are three capacitors in the circuit.

At the mid frequency band, these are considered to be short circuits and internal capacitors C'_{π}, and C'_{μ} are considered to be open circuits.

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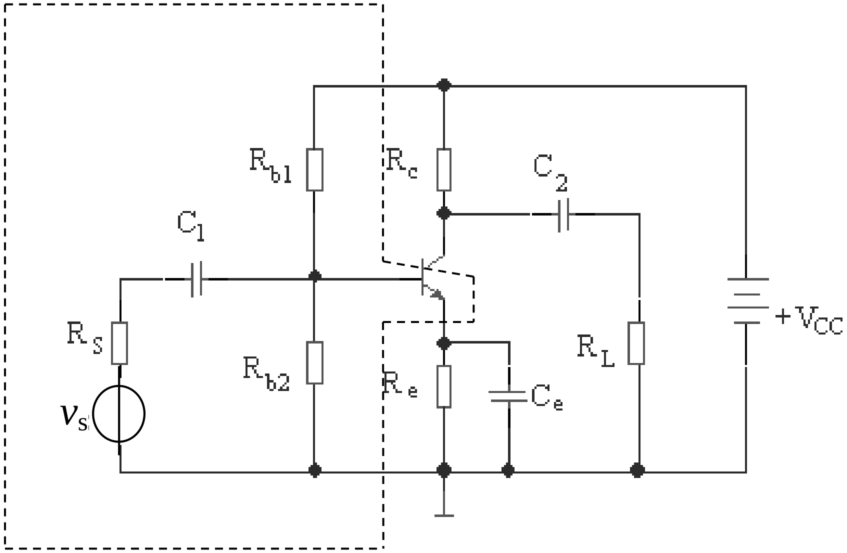
Frequency Response of the CE Amplifier



At low frequencies, $C_{1,}$ C_2 are an open circuit and the gain is zero. Thus C_1 has a high pass effect on the gain, i.e. it affects the lower cutoff frequency of the amplifier.

$$\tau_1 = C_1(R_s + R_{b1} // R_{b2} // r_{be})$$

$$f_{L1} = \frac{1}{2\pi\tau_1}$$

τ_2 is the time constant for C_2. $\Longrightarrow \tau_2 >> \tau_1$ ---is neglected

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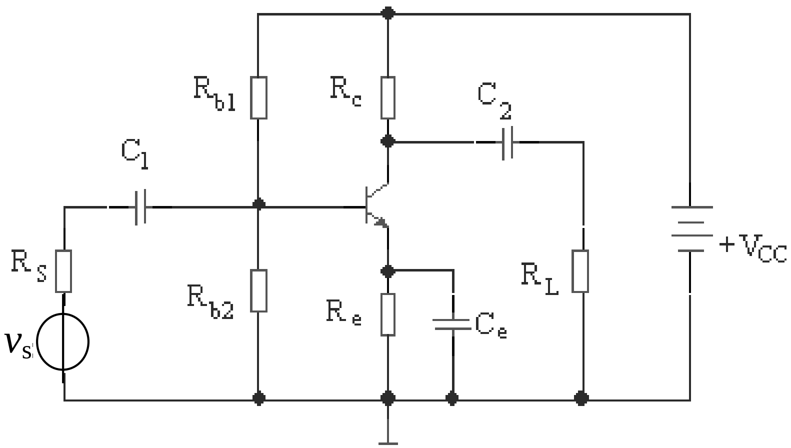
Frequency Response of the CE Amplifier



$$\tau_1 = C_1(R_s + R_{b1} // R_{b2} // r_{be})$$

$\tau_2 >> \tau_1$ ---is neglected

Capacitor Ce is an open circuit. The pole time constant is given by the resistance multiplied by Ce.

$$\tau_e = \left(\frac{(R_b // R_s + r_{be})}{1+\beta} // R_e \right) C_e$$

$$f_L \approx 1.1\sqrt{f_{L1}{}^2 + f_{L2}{}^2 + \cdots\cdots f_{Le}'{}^2}$$

$$f_{Le} = \frac{1}{2\pi\tau_e}$$

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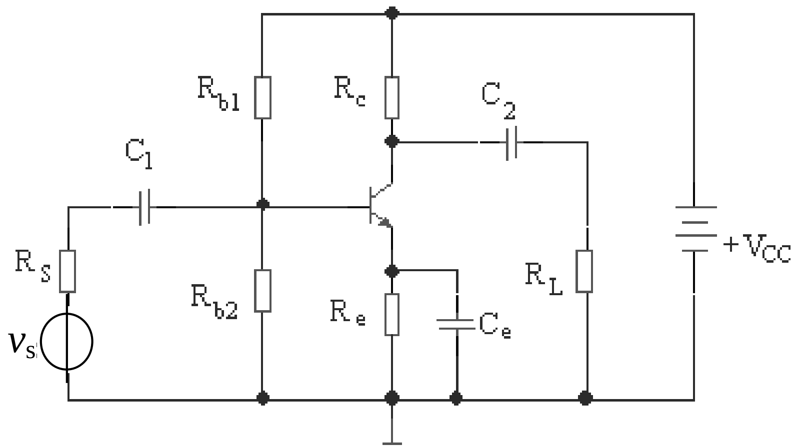
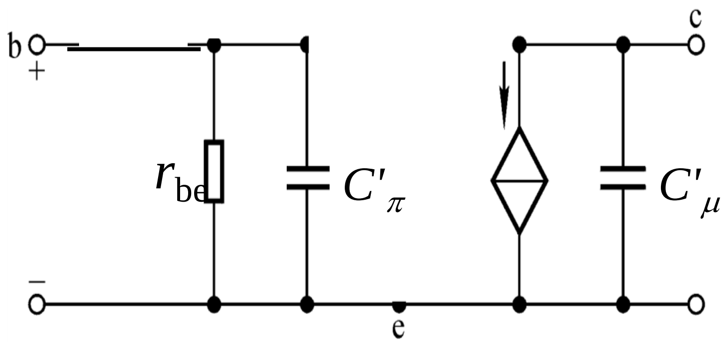
Frequency Response of the CE Amplifier





At high frequencies, C_1, C_2, C_e are all short circuit.

The frequency that dominates is the lowest pole frequency.

The time constant is neglected for C'_μ

$$(R'_L << 1/j\omega C'_\mu)$$

$$\tau_{C'_\pi} = (R_b // R_s // r_{be})C'_\pi$$

$$f_H = \frac{1}{2\pi\tau_{C'_\pi}}$$

In summary:the lower cut off frequency is determined by network capacitence. e.g.$C_1(C_2, C_e)$ The higher cut off frequency is determined by the parasitic ferquency of the BJT. e.g. C'_π

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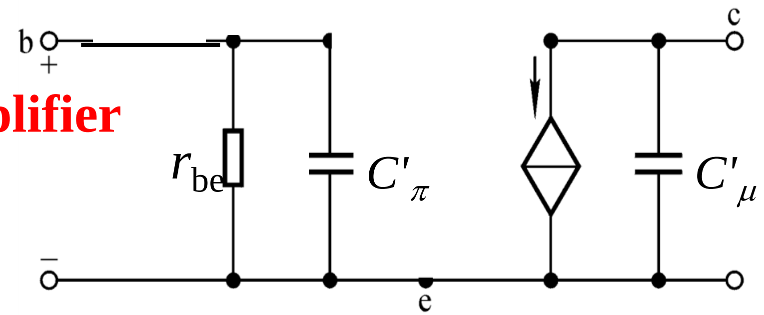
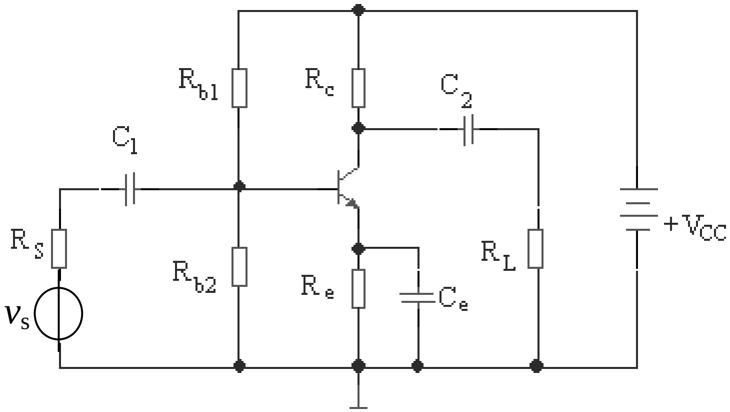
Frequency Response of the CE Amplifier





$$\dot{A}_v = A_{vm} \cdot \frac{j\frac{f}{f_L}}{(1+j\frac{f}{f_L})(1+j\frac{f}{f_H})}$$

$$For\ \ f_L << f << f_H,\quad \frac{f}{f_L} \to \infty, \quad \frac{f}{f_H} \to 0 \Rightarrow \dot{A}_v = A_{vm} \text{ — mid-frequency}$$

$$For\ \ f < f_L\ (f << f_H), \quad \frac{f}{f_H} \to 0, \Rightarrow \dot{A}_v = A_{vm}\frac{j\frac{f}{f_L}}{1+j\frac{f}{f_L}} \text{ — low-frequency}$$

$$For\ \ f > f_H\ (f >> f_L)\frac{f_L}{f} \to 0, \Rightarrow \dot{A}_v = A_{vm}\frac{1}{1+j\frac{f}{f_H}} \text{ — } High - frequency$$

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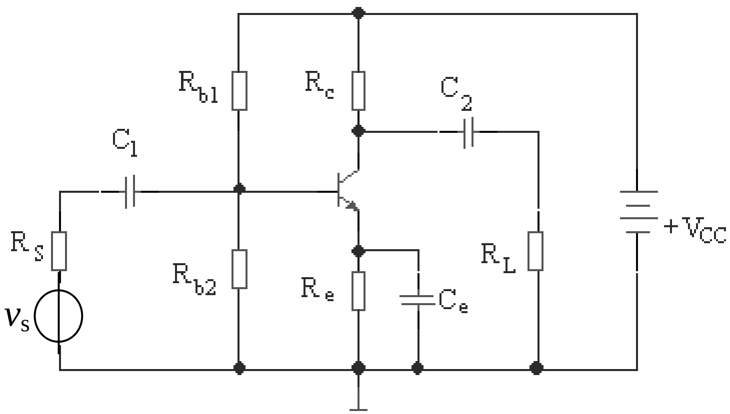

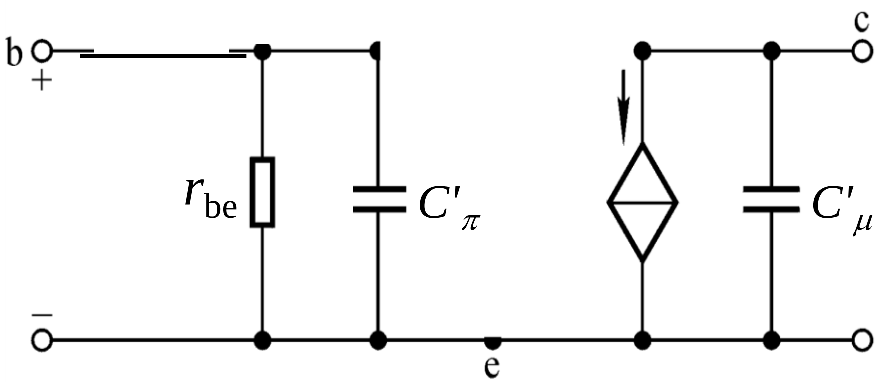

$$\dot{A}_v = A_{vm} \cdot \frac{j\frac{f}{f_L}}{(1+j\frac{f}{f_L})(1+j\frac{f}{f_H})}$$

$$f_L = \frac{\omega_L}{2\pi} = \frac{1}{2\pi\tau_L} \qquad f_H = \frac{\omega_H}{2\pi} = \frac{1}{2\pi\tau_H}$$

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