Lecture 24

BJT

6.3 Frequency Response

Key Words:

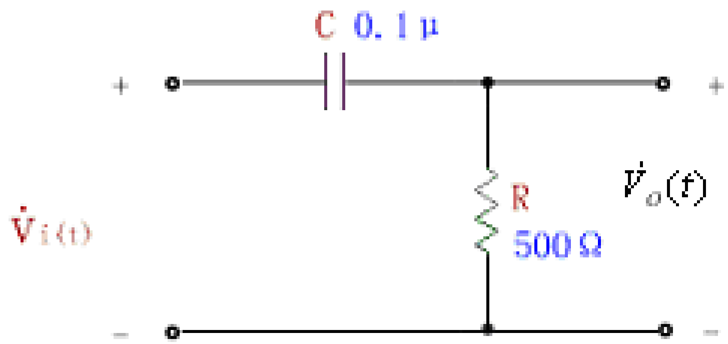
Basic Concepts

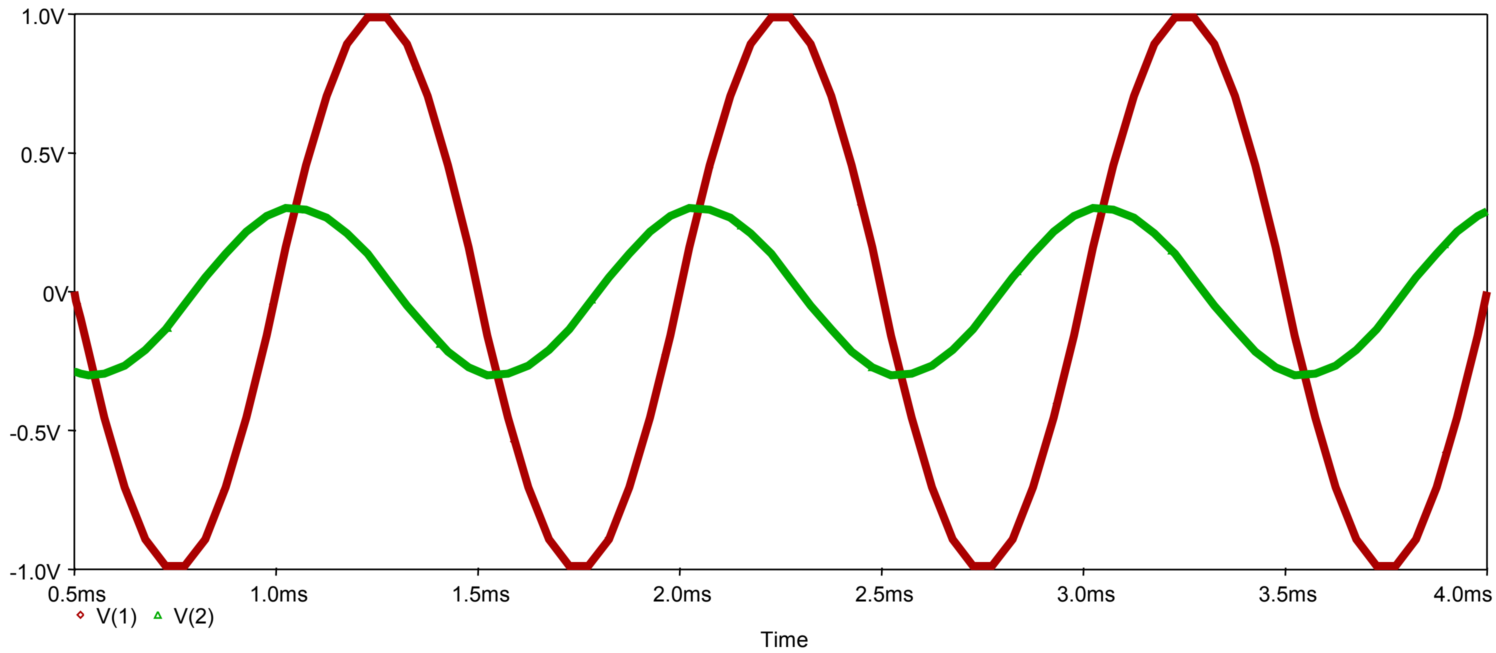
High-Frequency BJT Model

Frequency Response of the CE Amplifier

6.3 Frequency Response

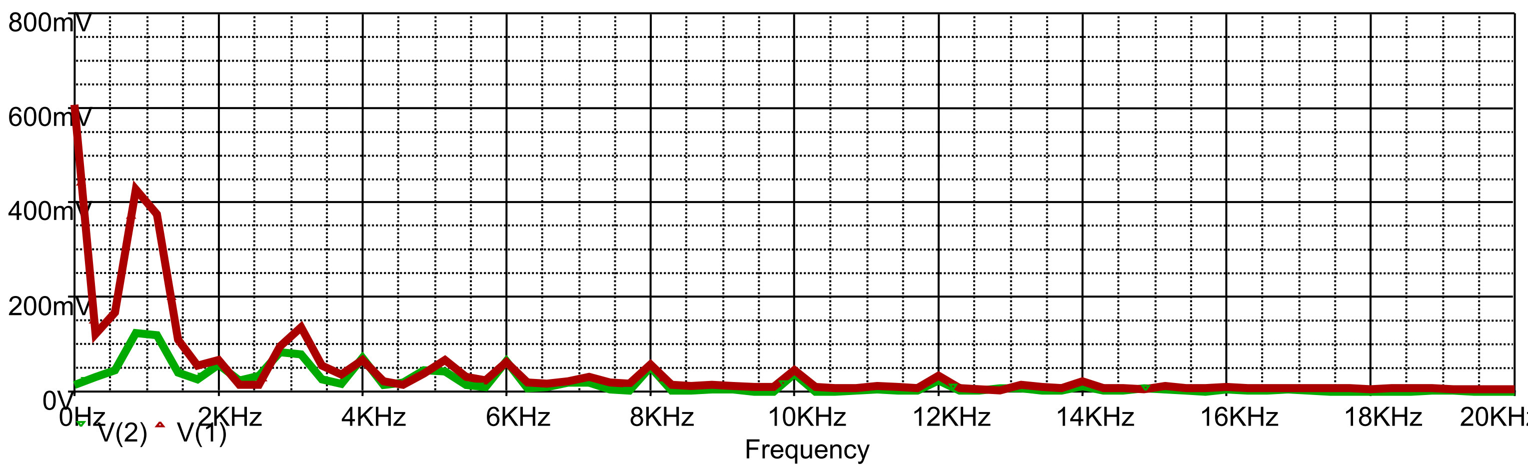
Basic Concepts

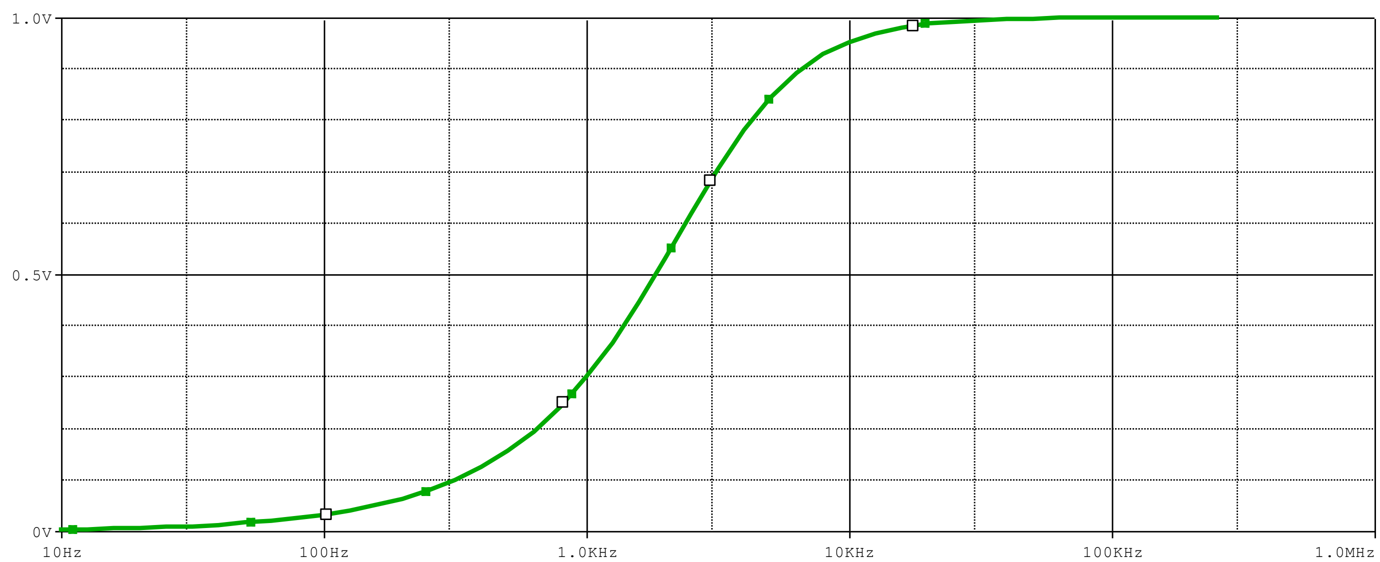




6.3 Frequency Response

Basic Concepts

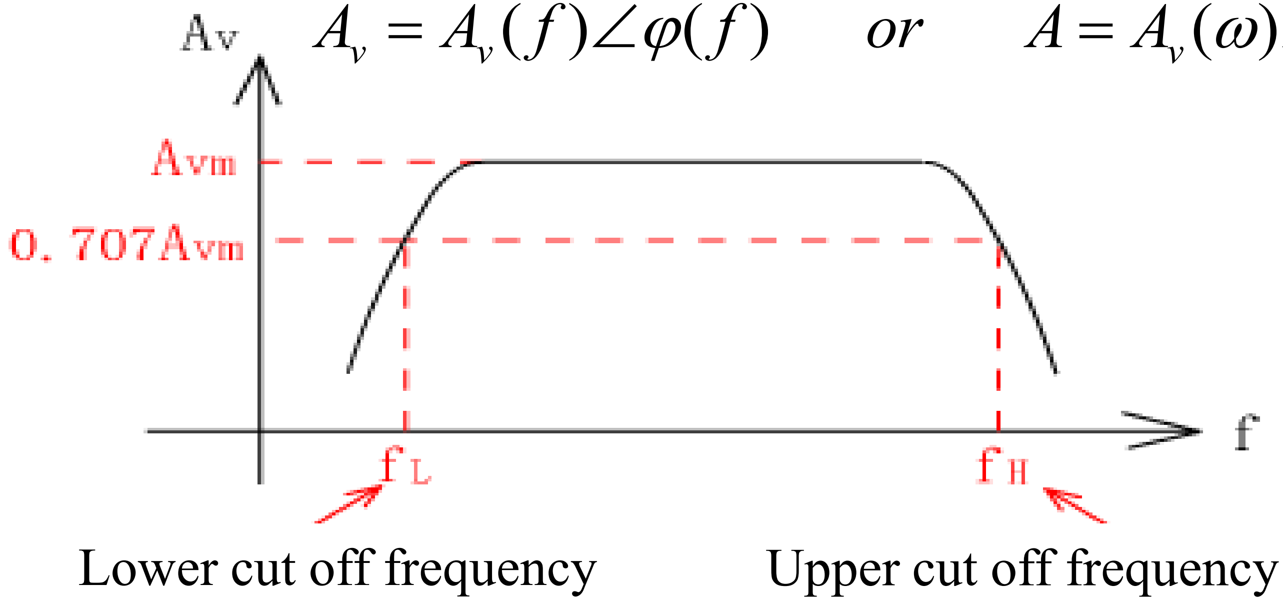




6.3 Frequency Response

Basic Concepts

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



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

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

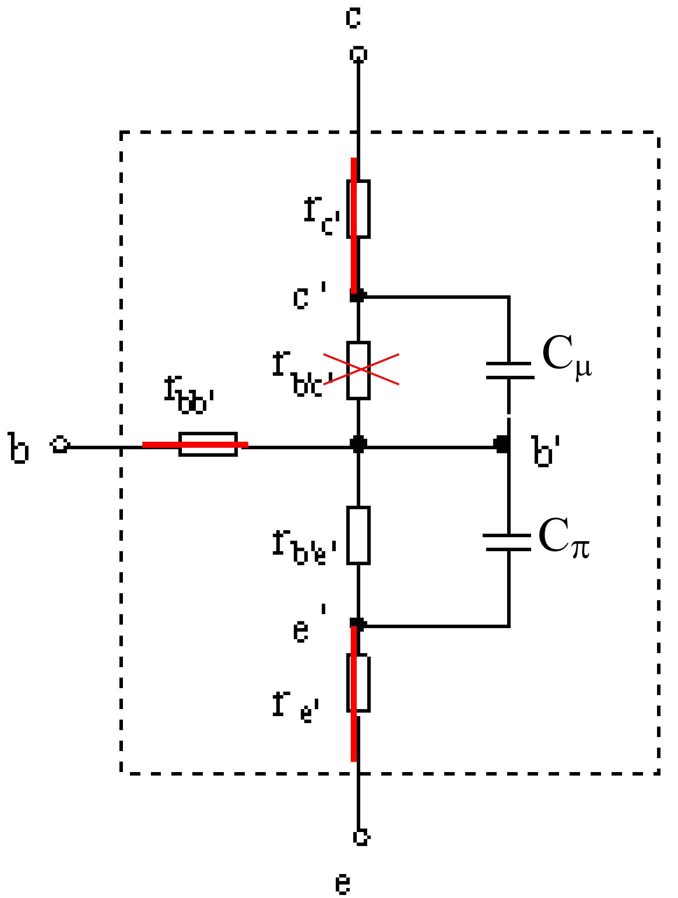
2、Parasitic capacitive elements of the network (at high *f*)

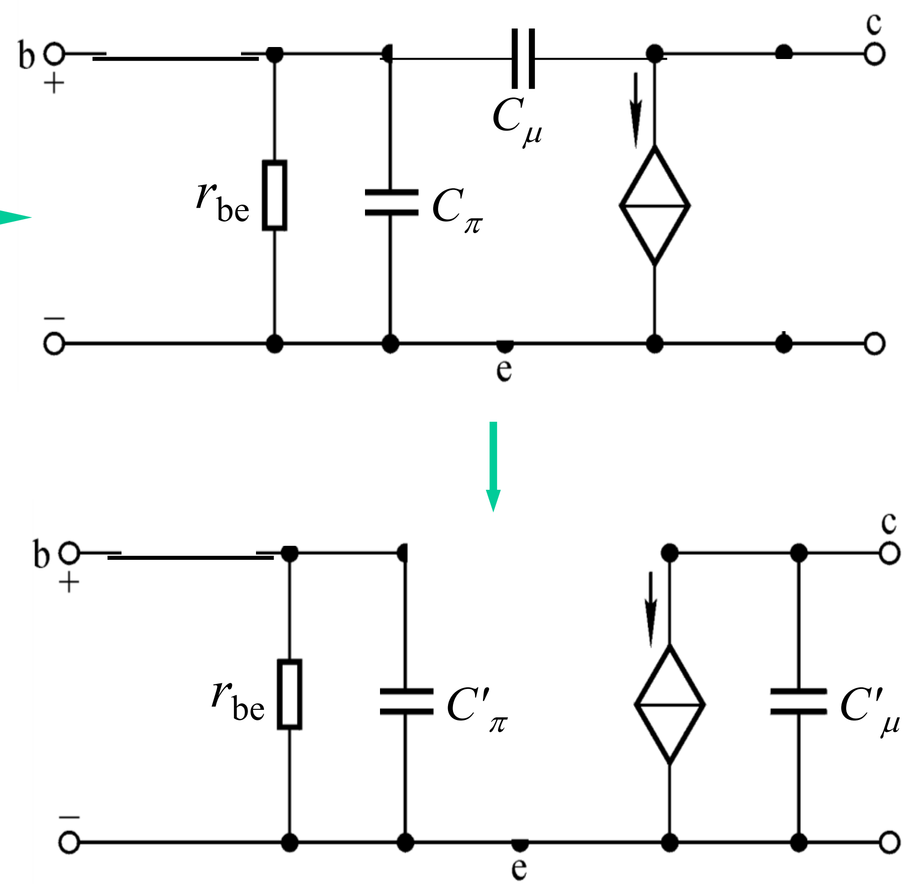
3、Dissappearance of changing current (for transformer coupled amp.)

6.3 Frequency Response

High-Frequency BJT Model

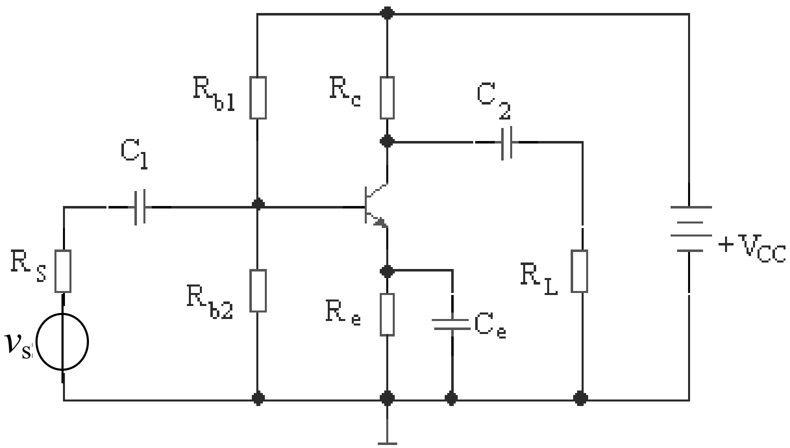
In BJTs, the PN junctions (EBJ and CBJ) also have capacitances associated with them

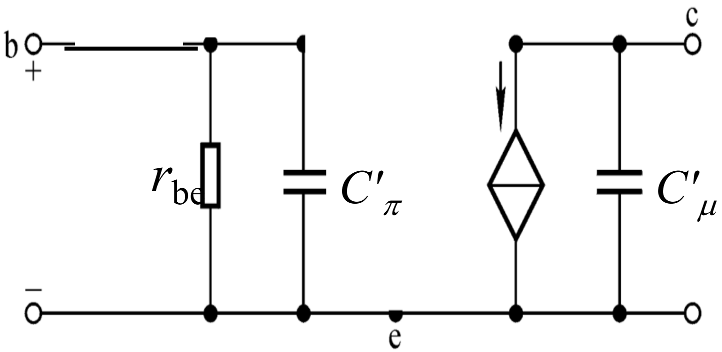




6.3 Frequency Response

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 $C'_{\pi},$ and C'_{μ} are considered to be open circuits.

6.3 Frequency Response

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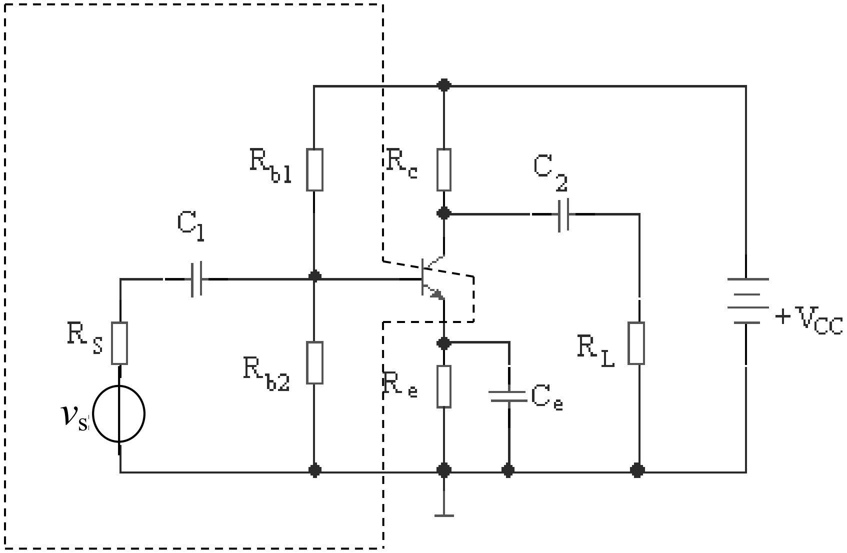

At low frequencies, C_1, C_2 are an open circuit and the gain is zero. Thus C_1 has a high pass effect on the gain, i.e. it affects the lower cutoff frequency of the amplifier.

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

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

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

6.3 Frequency Response

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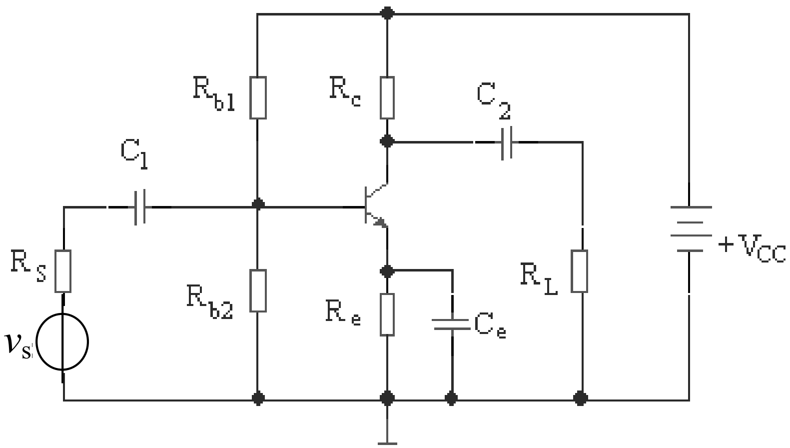


$$\tau_1 = C_1(R_s + R_{b1} // R_{b2} // r_{be})$$

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

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

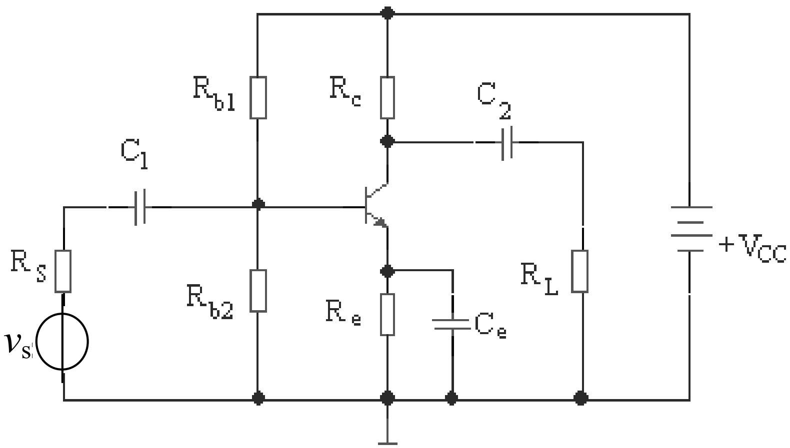
$$\tau_e = \left(\frac{(R_b // R_s + r_{be})}{1+\beta} // R_e \right) C_e$$

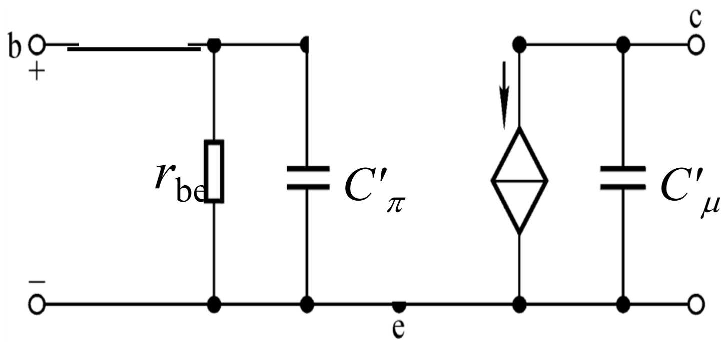
$$f_L \approx 1.1\sqrt{{f_{L1}}^2 + {f_{L2}}^2 + \cdots\cdots {f'_{Le}}^2}$$

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

6.3 Frequency Response

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

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

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

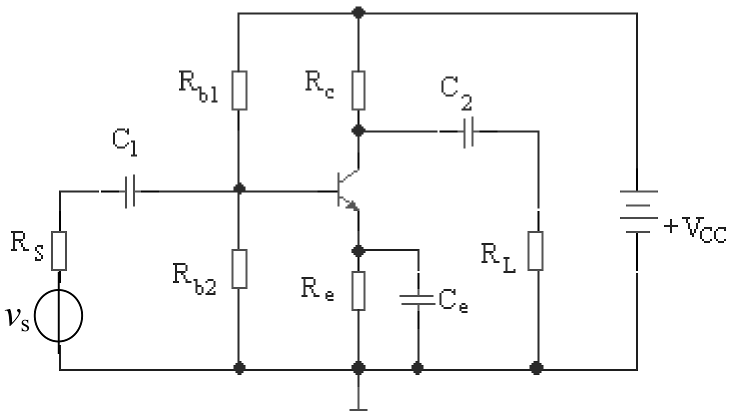
$$f_H = \frac{1}{2\pi\tau_{C'_\pi}}$$

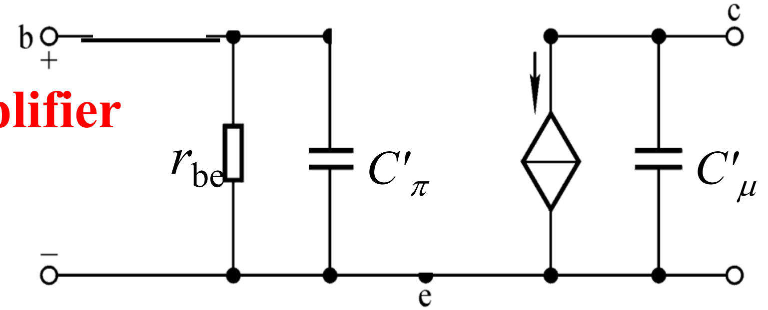
In summary:the lower cut off frequency is determined by network capacitence.

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

6.3 Frequency Response

Frequency Response of the CE Amplifier





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

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

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

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

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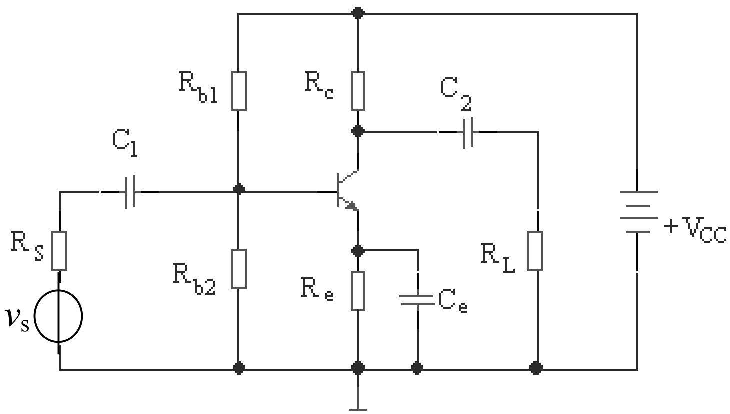

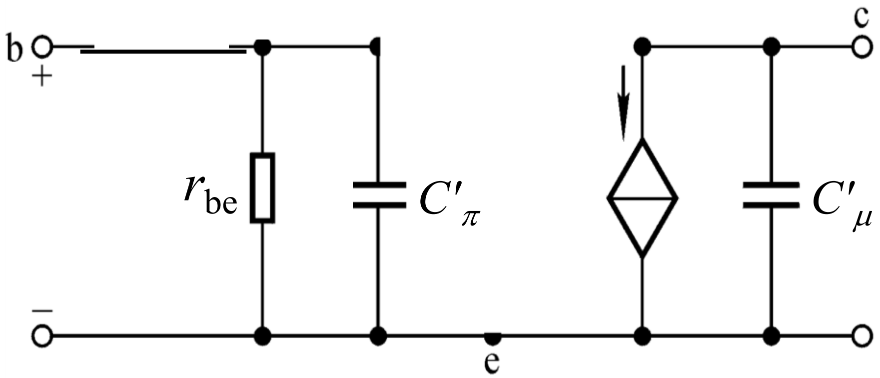

$$\dot{A}_v = A_{vm} \cdot \frac{j\frac{f}{f_L}}{(1+j\frac{f}{f_L})(1+j\frac{f}{f_H})}$$

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

6.3 Frequency Response

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