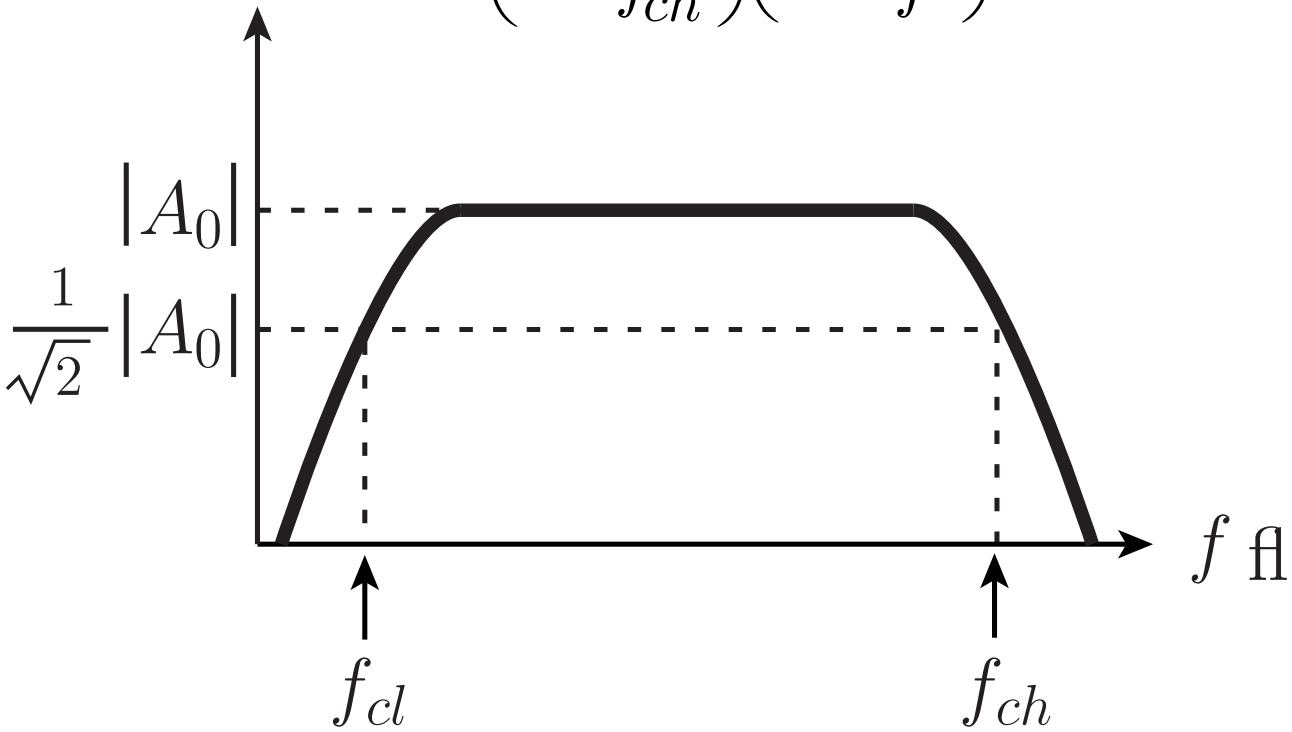
増幅回路の周波数特性

利得：$A=\dfrac{A_0}{\left(1+j\dfrac{f}{f_{ch}}\right)\left(1+j\dfrac{f_{cl}}{f}\right)}$



A_0: 中域利得

f_{cl}: 低域遮断周波数

f_{ch}: 高域遮断周波数

遮断周波数がf_{cl}およびf_{ch}であることの確認

$f \ll f_{ch}$のとき　$$A=\frac{A_0}{\left(1+j\frac{f}{f_{ch}}\right)\left(1+j\frac{f_{cl}}{f}\right)}\approx\frac{A_0}{1+j\frac{f_{cl}}{f}}$$

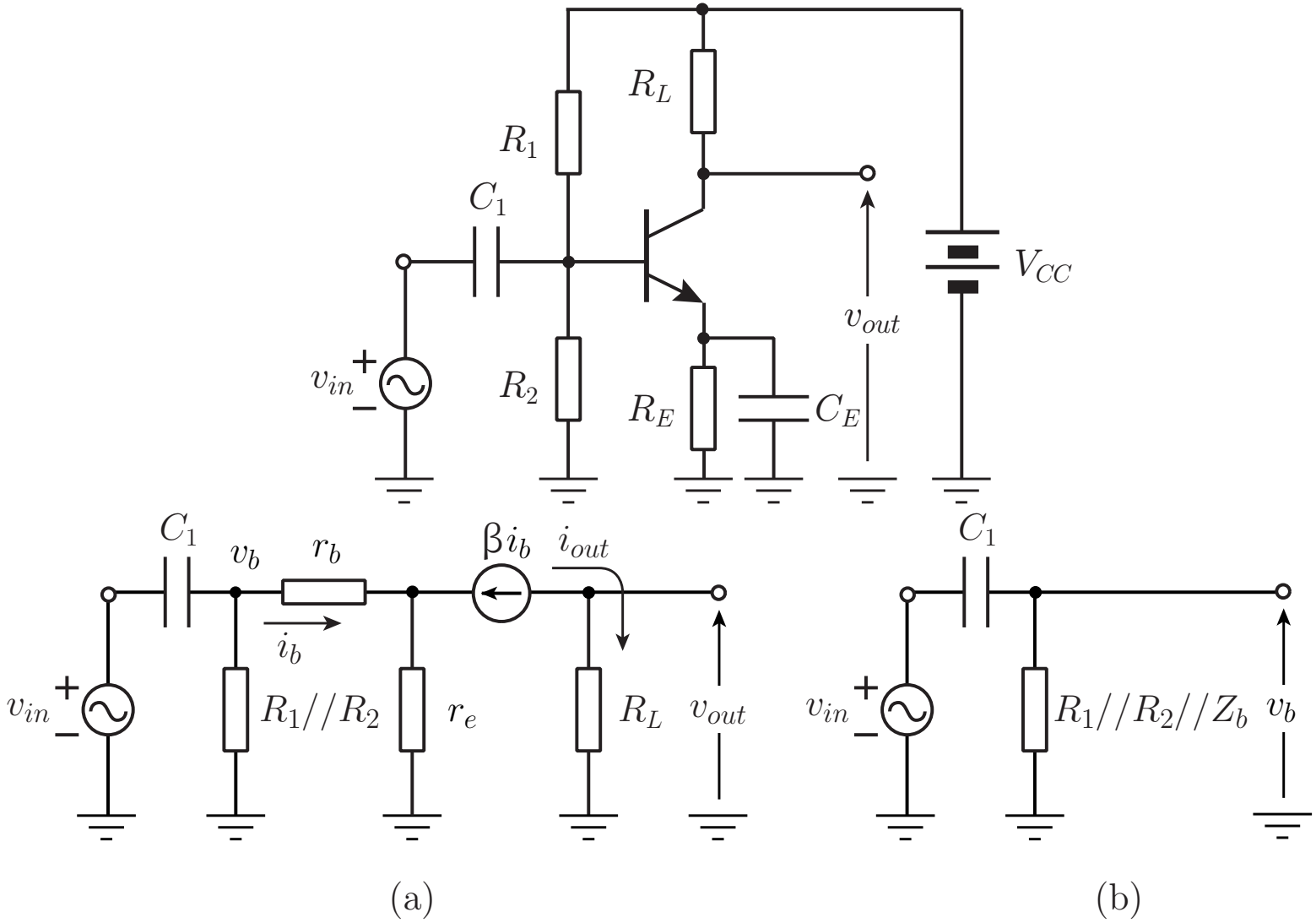
$f_{cl} \ll f$のとき　$$A=\frac{A_0}{\left(1+j\frac{f}{f_{ch}}\right)\left(1+j\frac{f_{cl}}{f}\right)}\approx\frac{A_0}{1+j\frac{f}{f_{ch}}}$$

$$\frac{|A_0|}{\left|1+j\frac{f_{cl}}{f}\right|_{f=f_{cl}}}\approx\frac{|A_0|}{\sqrt{2}}$$

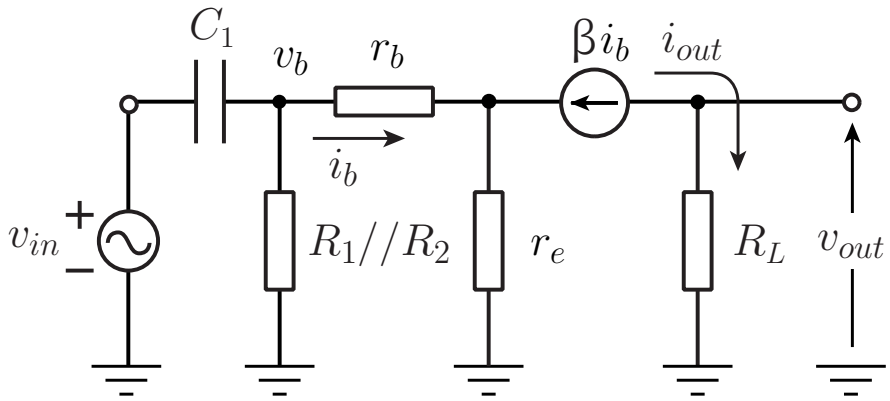
$$\frac{|A_0|}{\left|1+j\frac{f}{f_{ch}}\right|_{f=f_{ch}}}\approx\frac{|A_0|}{\sqrt{2}}$$

遮断周波数は分母だけで決まる！

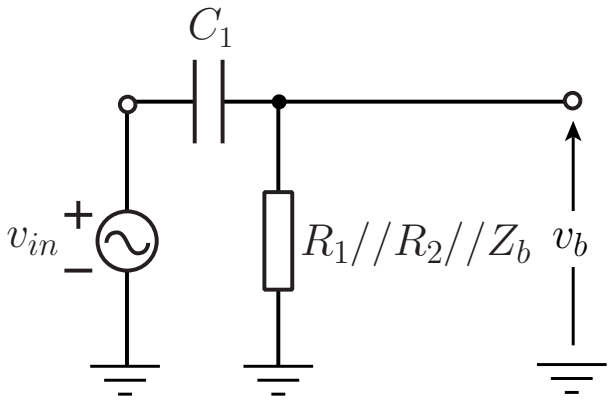
エミッタ接地増幅回路の低周波小信号モデル
(C_Eの値は十分大きいと仮定)



(a) (b)



(a)



(b)

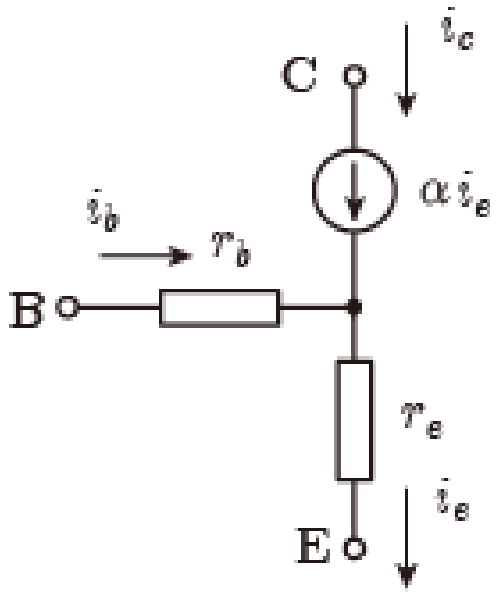
(a)⇒(b): ベースより右側を入力インピーダンスZ_bで置換

$$\frac{v_b}{v_{in}}=\frac{A_0}{1+\dfrac{1}{j\omega C_1(R_1//R_2//Z_b)}}$$

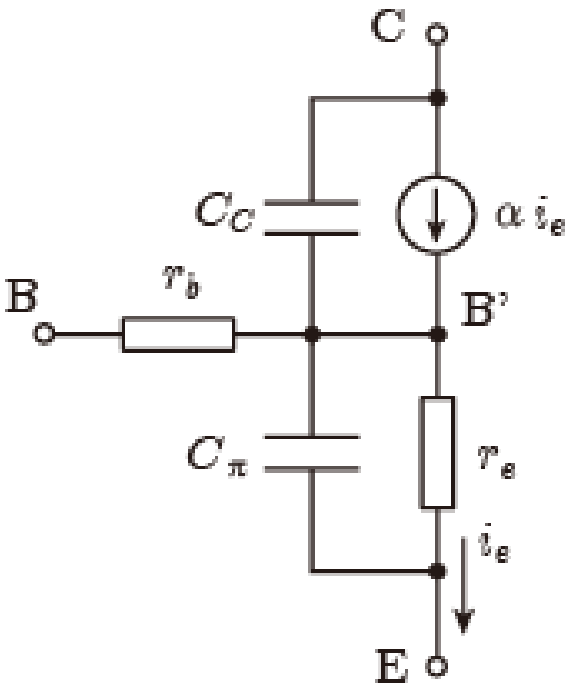
v_{out}はv_bの実数倍⇒分母に変化無し

$$f_{cl}=\frac{1}{2\pi C_1(R_1//R_2//Z_b)}$$

バイポーラトランジスタの高周波小信号モデル



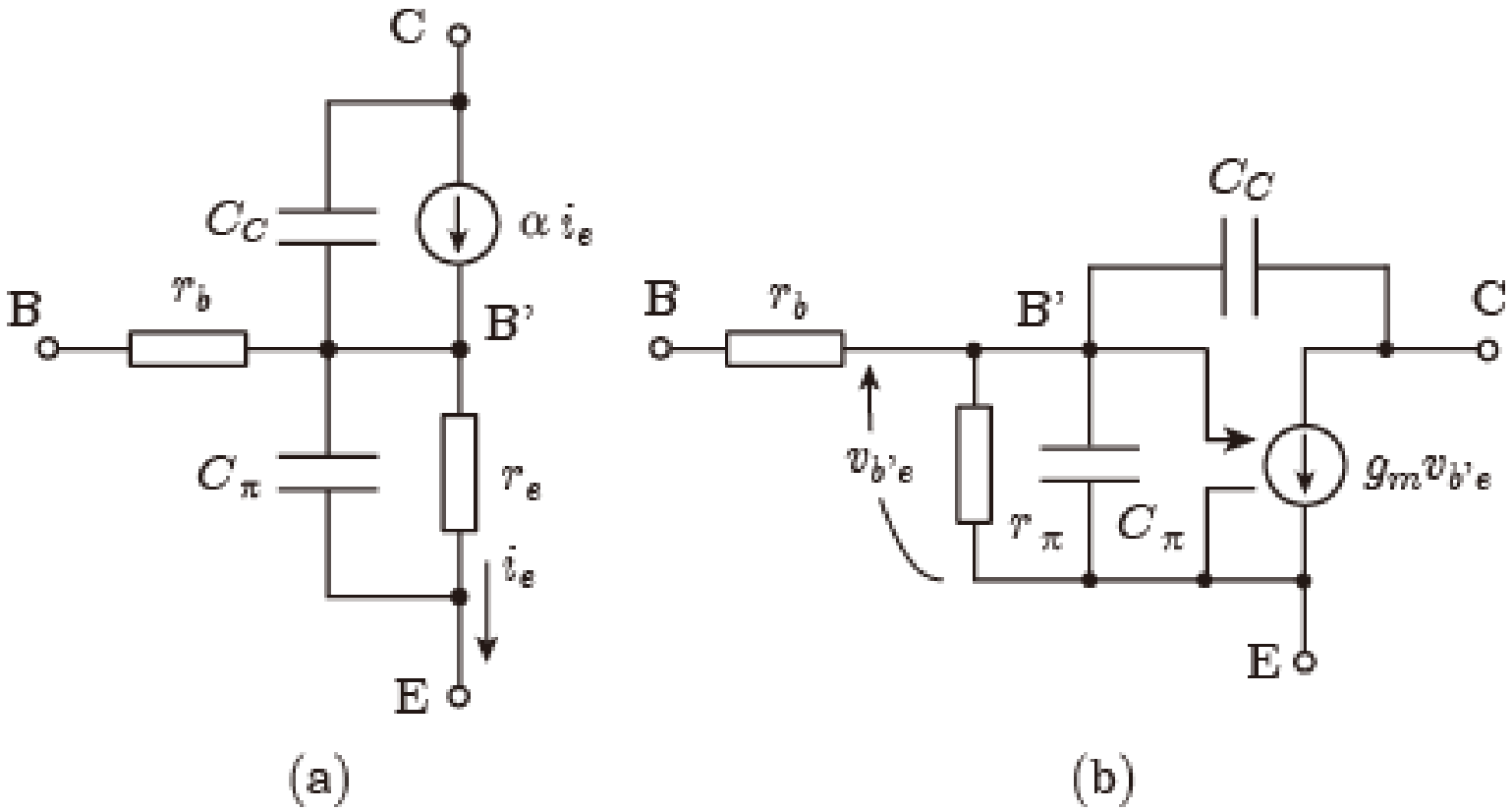
寄生容量を考慮



$$\alpha = \frac{\alpha_0}{1 + j\dfrac{\omega}{\omega_\alpha}}$$

$\omega_\alpha = \dfrac{1}{C_\pi r_e}$: 電流増幅率遮断角周 波数

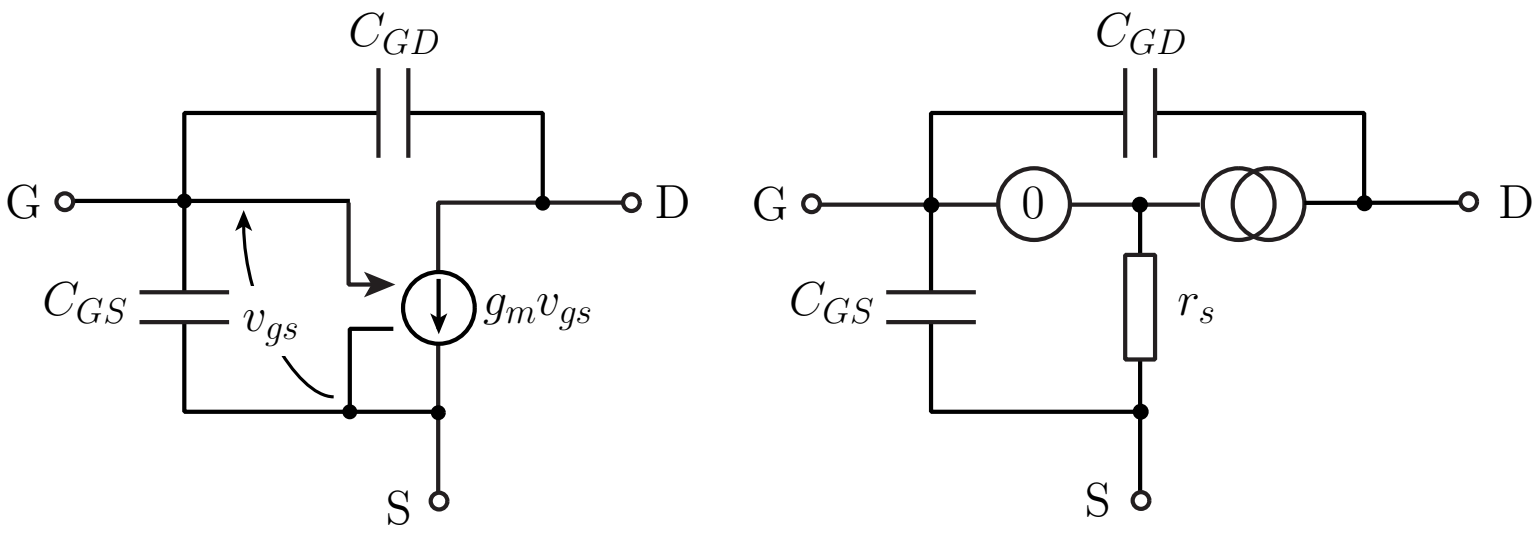
等価変換



$$r_\pi = \frac{r_e}{1-\alpha_0} \qquad g_m = \frac{\alpha_0}{r_e}$$

MOSトランジスタの高周波小信号モデル

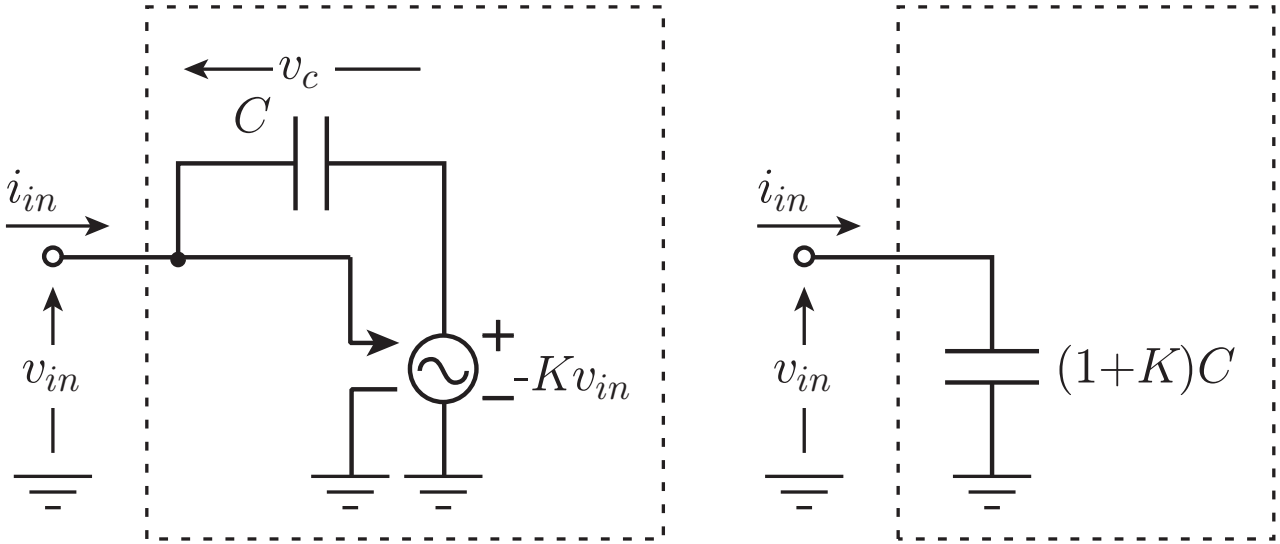
基板間の寄生容量を考慮



(a) (b)

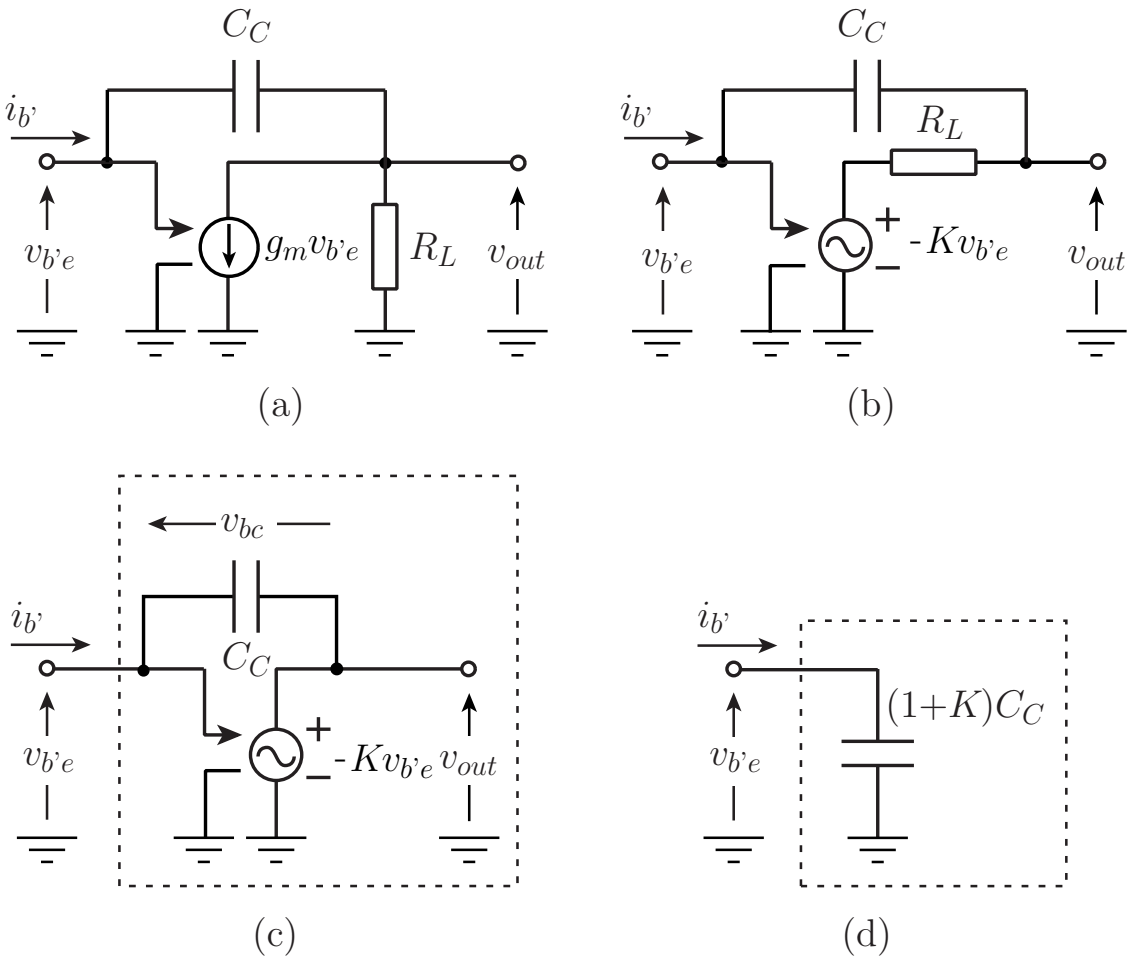
ミラー効果

等価変換

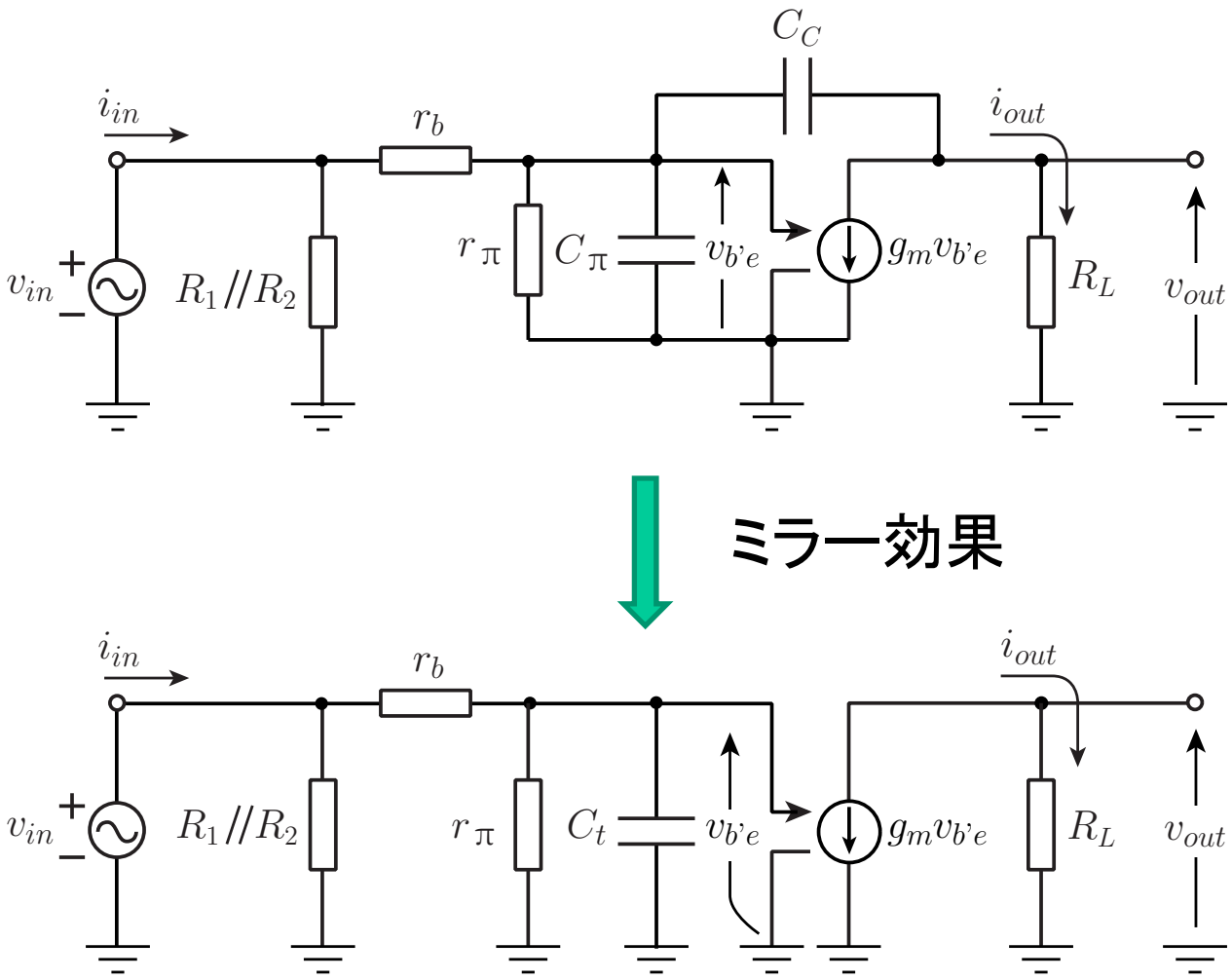


$$v_c = v_{in} - (-Kv_{in}) = (1+K)v_{in}$$

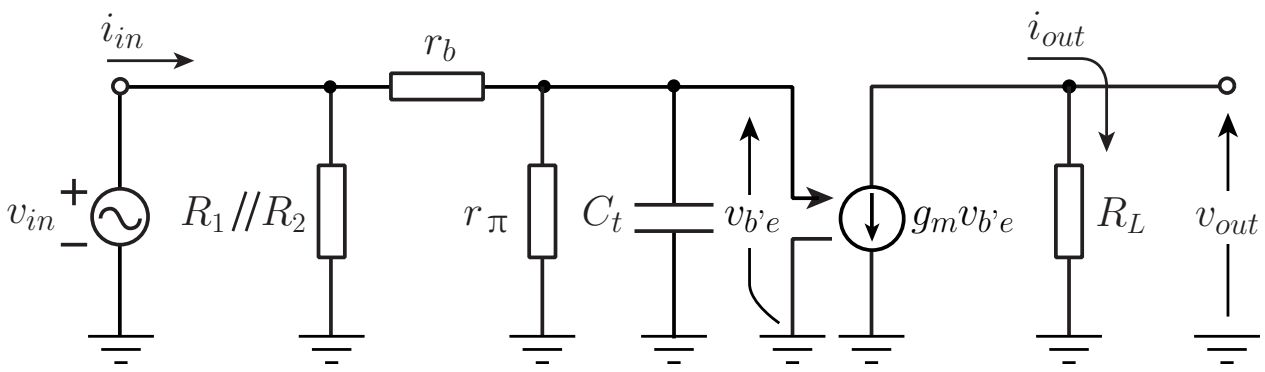
$$i_{in} = j\omega C v_c = j\omega C(1+K)v_{in} \qquad i_{in} = j\omega C(1+K)v_{in}$$



$$\boxed{\text{(b)}\Rightarrow\text{(c)}:\ R_L << \frac{1}{\omega C_c}\text{と近似}}$$


C_C
i_{in}
r_b
i_{out}
v_{in}
$R_1//R_2$
r_π
C_π
$v_{b'e}$
$g_m v_{b'e}$
R_L
v_{out}
ミラー効果
i_{in}
r_b
i_{out}
v_{in}
$R_1//R_2$
r_π
C_t
$v_{b'e}$
$g_m v_{b'e}$
R_L
v_{out}

$$C_t = C_\pi + (1+K)C_C$$



$$v_{b'e}=\frac{\frac{1}{r_b}v_{in}}{\frac{1}{r_b}+\frac{1}{r_\pi}+j\omega C_t}=\frac{r_\pi v_{in}}{r_b+r_\pi+j\omega C_t r_b r_\pi}$$

$$v_{out}=-g_m R_L v_{b'e}$$

v_{out}は$v_{b'e}$の実数倍⇒分母に変化無し

$$f_{ch}=\frac{r_b+r_\pi}{2\pi C_t r_b r_\pi}$$

$$A_0=\frac{-g_m R_L r_\pi}{r_b+r_\pi+j\omega C_t r_b r_\pi}$$