Respons Frekuensi

Elektronika
(TKE 4012)

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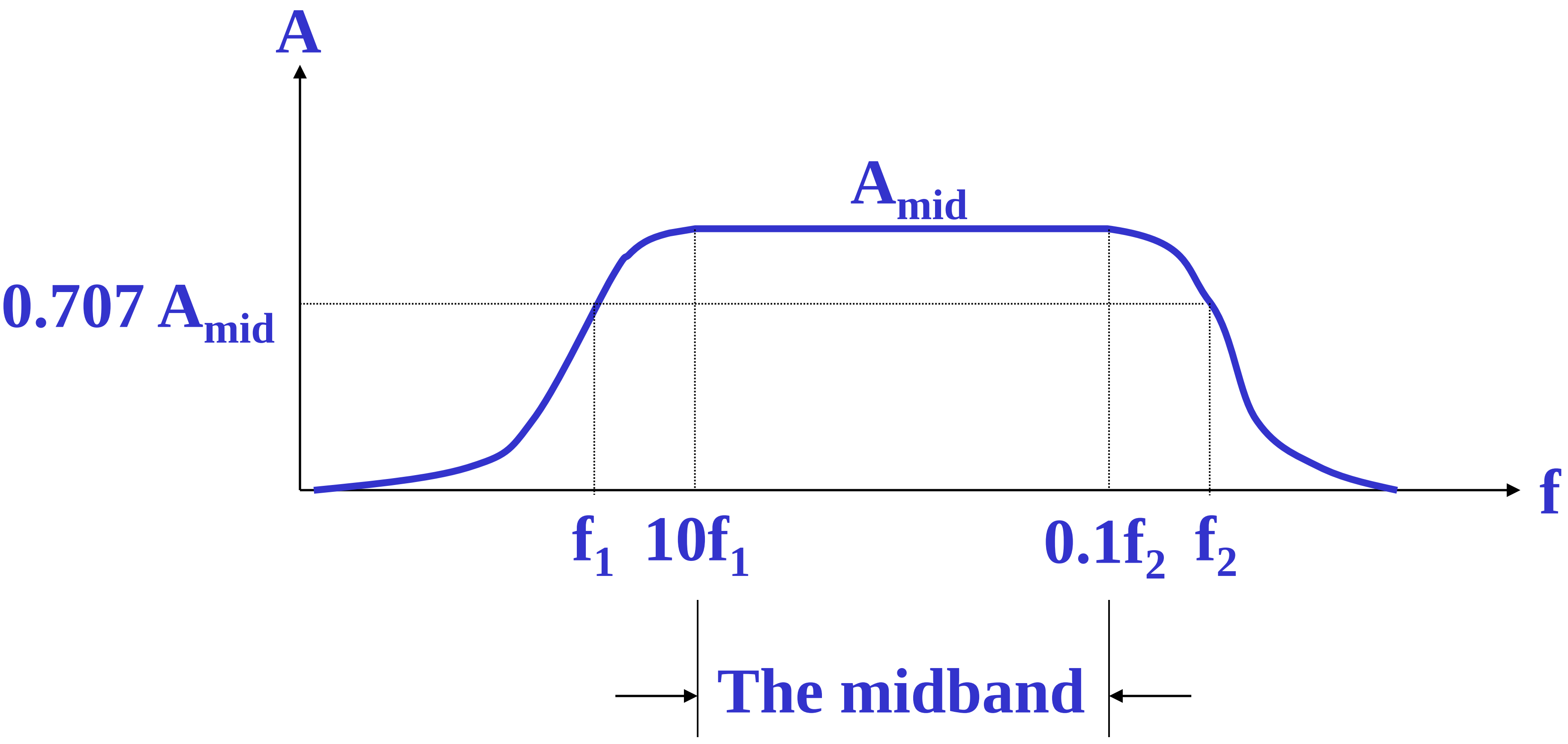
The frequency response curve of an ac amplifier



The gain is maximum in the midband.

Review of logarithms

- A logarithm is an exponent
- If $x = 10^y$, then $y = \log_{10}x$
- $y = \log 10 = 1$
- $y = \log 100 = 2$
- $y = \log 1000 = 3$
- $y = \log 0.1 = -1$
- $y = \log 0.01 = -2$
- $y = \log 0.001 = -3$

Definition of G_{dB}

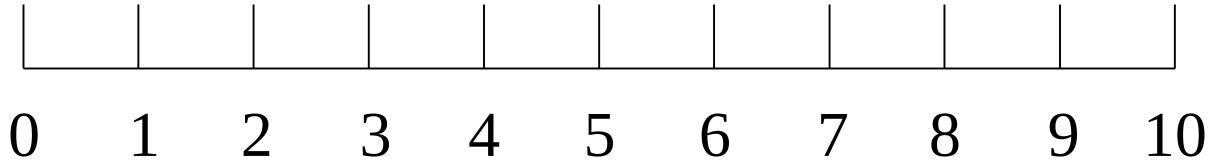
- $G = p_{out}/p_{in}$
- $G_{dB} = 10 \log G$
- Memorize:
  - if $G = 2$, $G_{dB} = +3$
  - if $G = 0.5$, $G_{dB} = -3$
  - if $G = 10$, $G_{dB} = +10$
  - if $G = 0.1$, $G_{dB} = -10$

Definition of A_{dB}

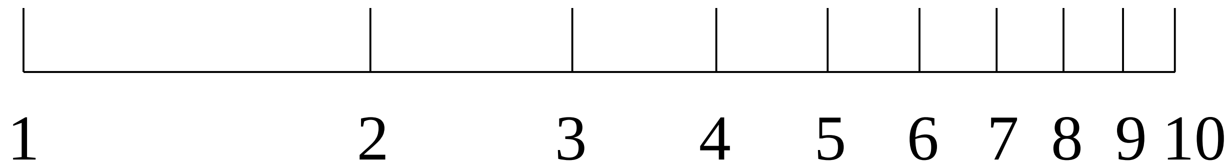
- $A = v_{out}/v_{in}$
- $A_{db} = 20 \log A$
- Memorize:
  - > if $A = 2$, $A_{dB} = +6$
  - > if $A = 0.5$, $A_{dB} = -6$
  - > if $A = 10$, $A_{dB} = +20$
  - > if $A = 0.1$, $A_{dB} = -20$
- Cascade: $A = A_1 A_2$, $A_{dB} = A_{1dB} + A_{2dB}$

More on the decibel

- $G_{dB} = A_{dB}$ only if *impedance matched*
- $G = \text{antilog } G_{dB}/10$
- $A = \text{antilog } A_{dB}/20$
- $P_{dBm} = 10 \log P/1 \text{ mW}$
- $P = \text{antilog } P_{dBm}/10$
- $V_{dBV} = 20 \log V$
- $V = \text{antilog } V_{dBV}/20$



Linear scale



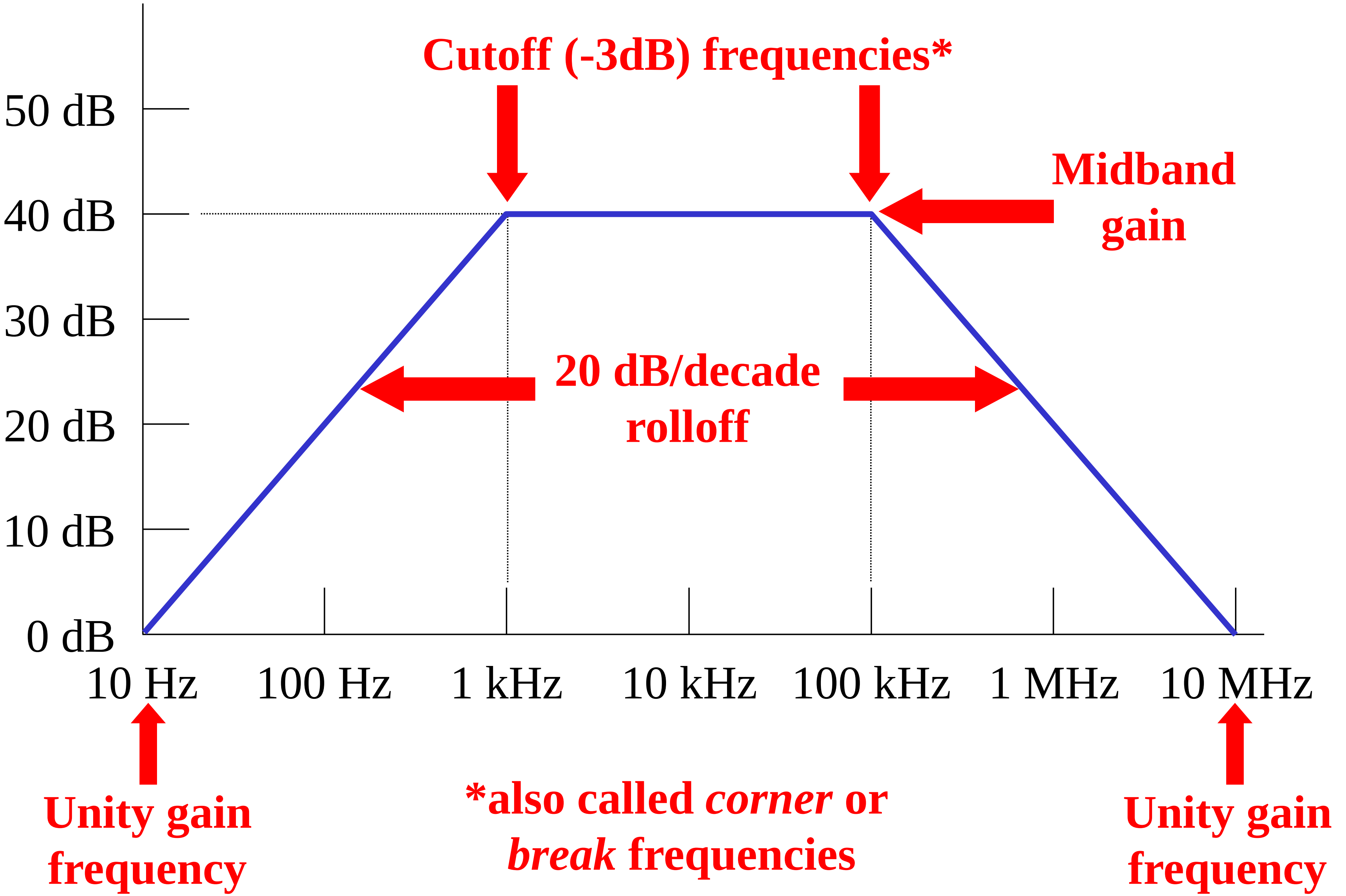
Logarithmic scale

A logarithmic scale compresses large values and allows a large range to be covered without losing resolution for the smaller values.

Bode plots

- Use semilogarithmic graph paper (the horizontal axis is logarithmic; the vertical is linear)
- Plot dB voltage gain on the vertical axis
- Plot frequency on the horizontal axis
- An octave refers to a ratio of 2
- A decade refers to a ratio of 10

Ideal Bode plot of an ac amplifier

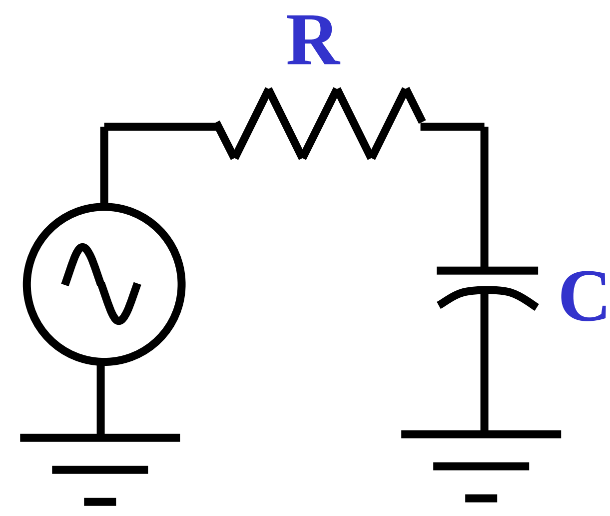


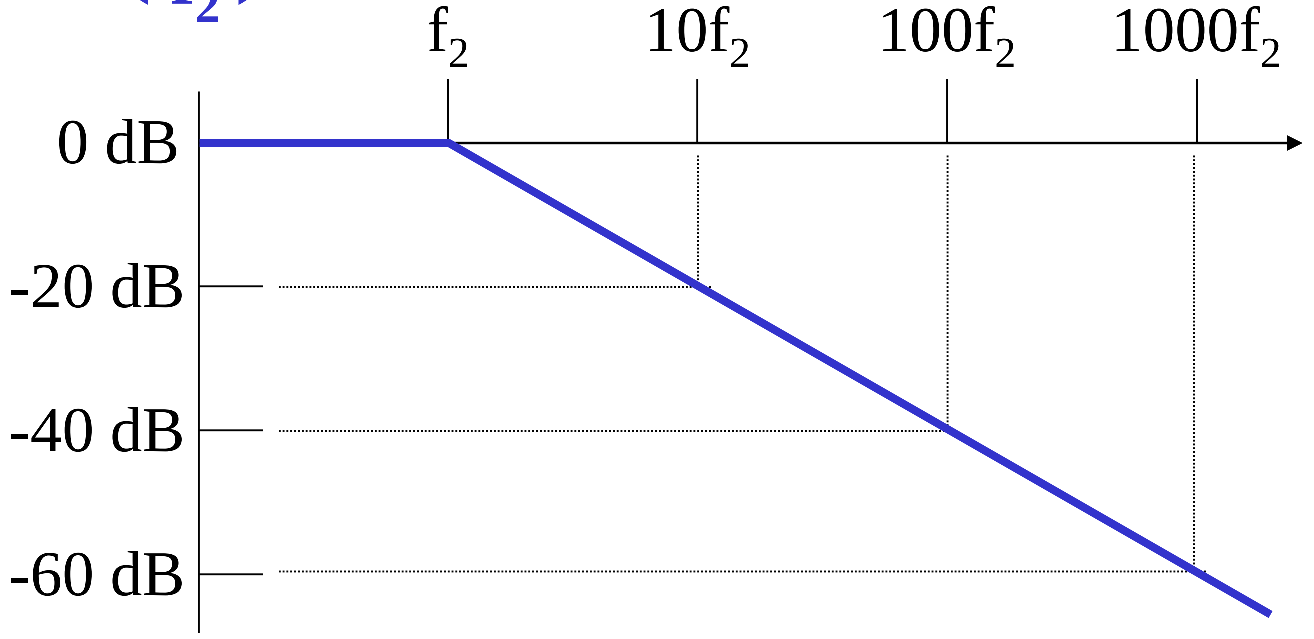
***also called *corner* or *break* frequencies**

Amplitude response of RC lag circuit

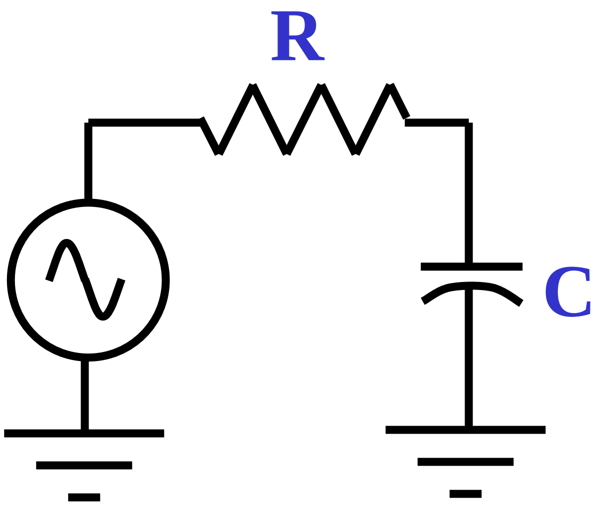
$$f_2 = \frac{1}{2\pi RC}$$

$$A = \frac{1}{\sqrt{1+\left(\frac{f}{f_2}\right)^2}}$$

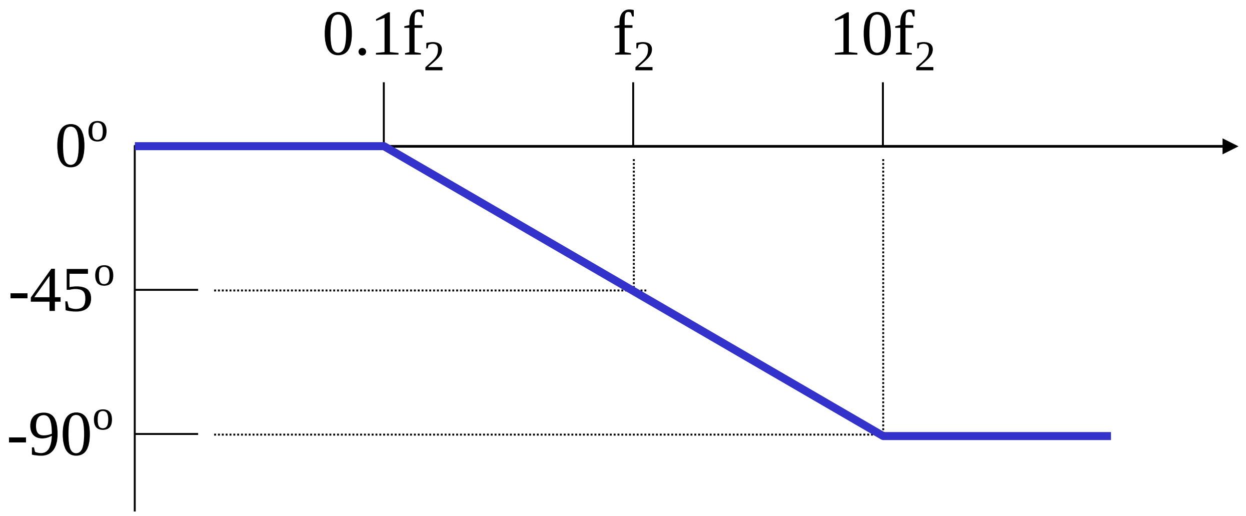




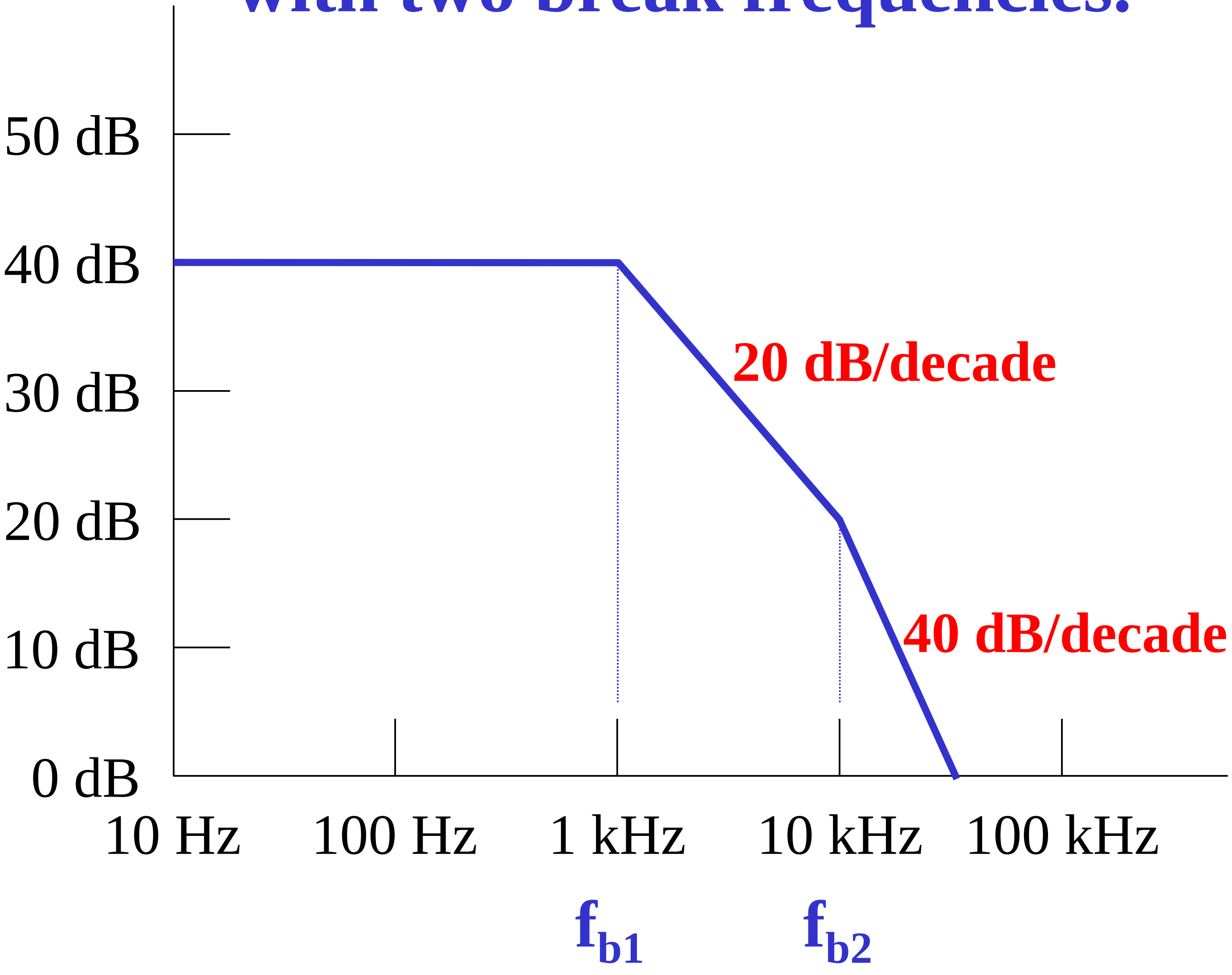
Angular response of RC lag circuit

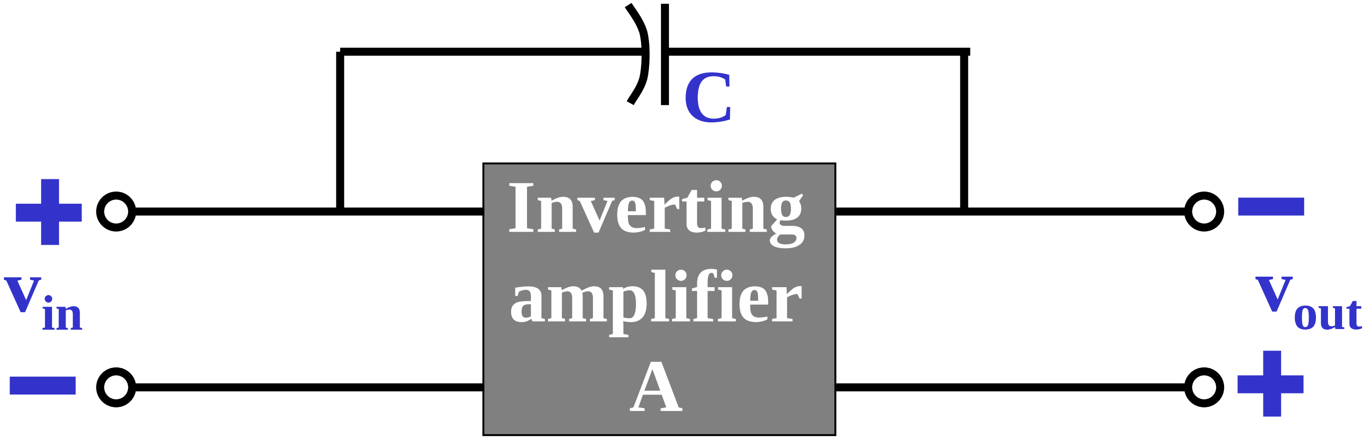


$$\phi = -\arctan \frac{f}{f_2}$$

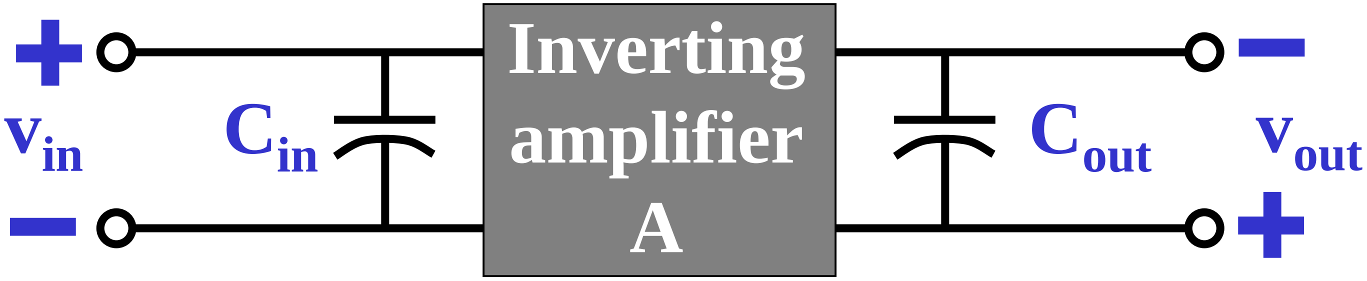


Ideal Bode plot of a dc amplifier with two break frequencies.





Inverting amplifier with feedback capacitor



Miller equivalent circuit

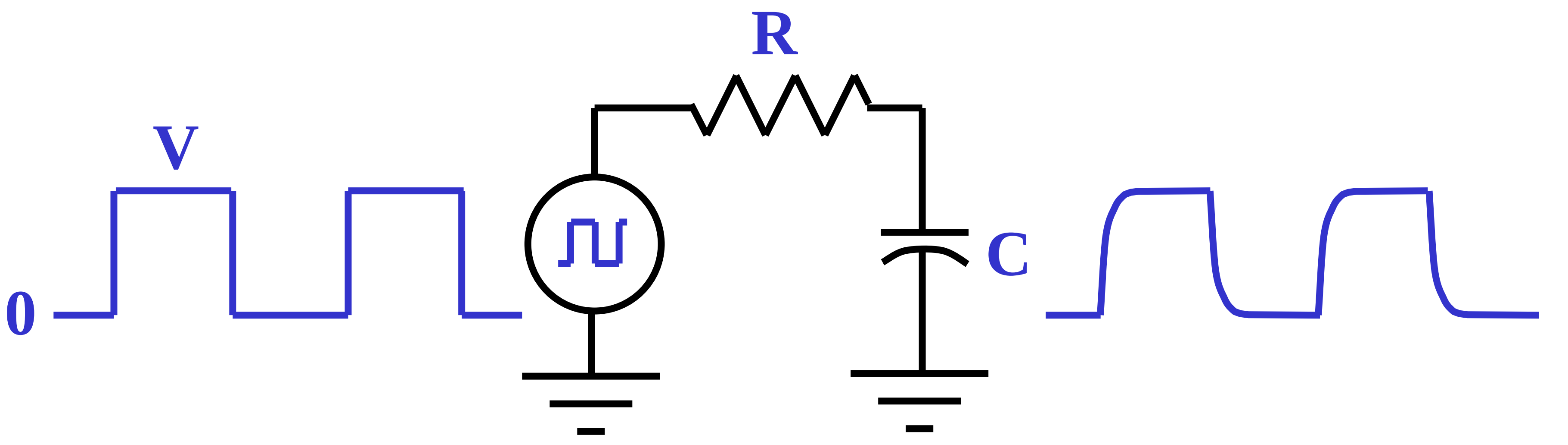
$$C_{in} = C(A+1)$$

$$C_{out} = C\,\frac{A+1}{A}$$

Frequency compensation

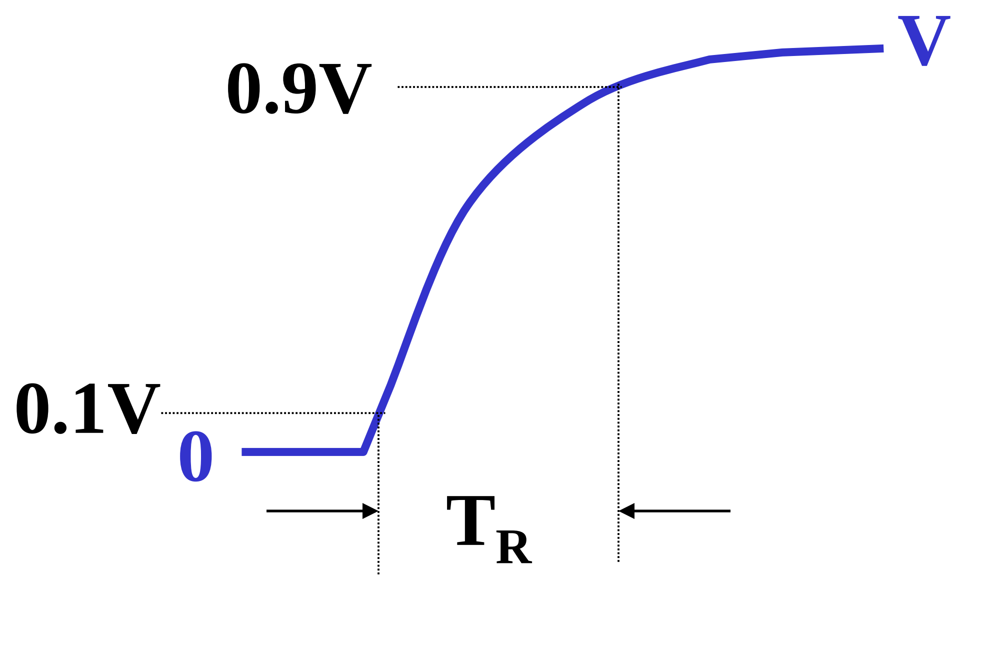
- Most op amps are internally compensated to prevent oscillations
- One dominant internal compensation capacitor rolls off the gain at 20 dB/decade
- IC capacitors are limited to the pF range
- The Miller effect makes the internal compensation capacitor equivalent to a much larger capacitor

Square-wave response of a circuit with limited bandwidth



$$T_R = 2.2RC$$

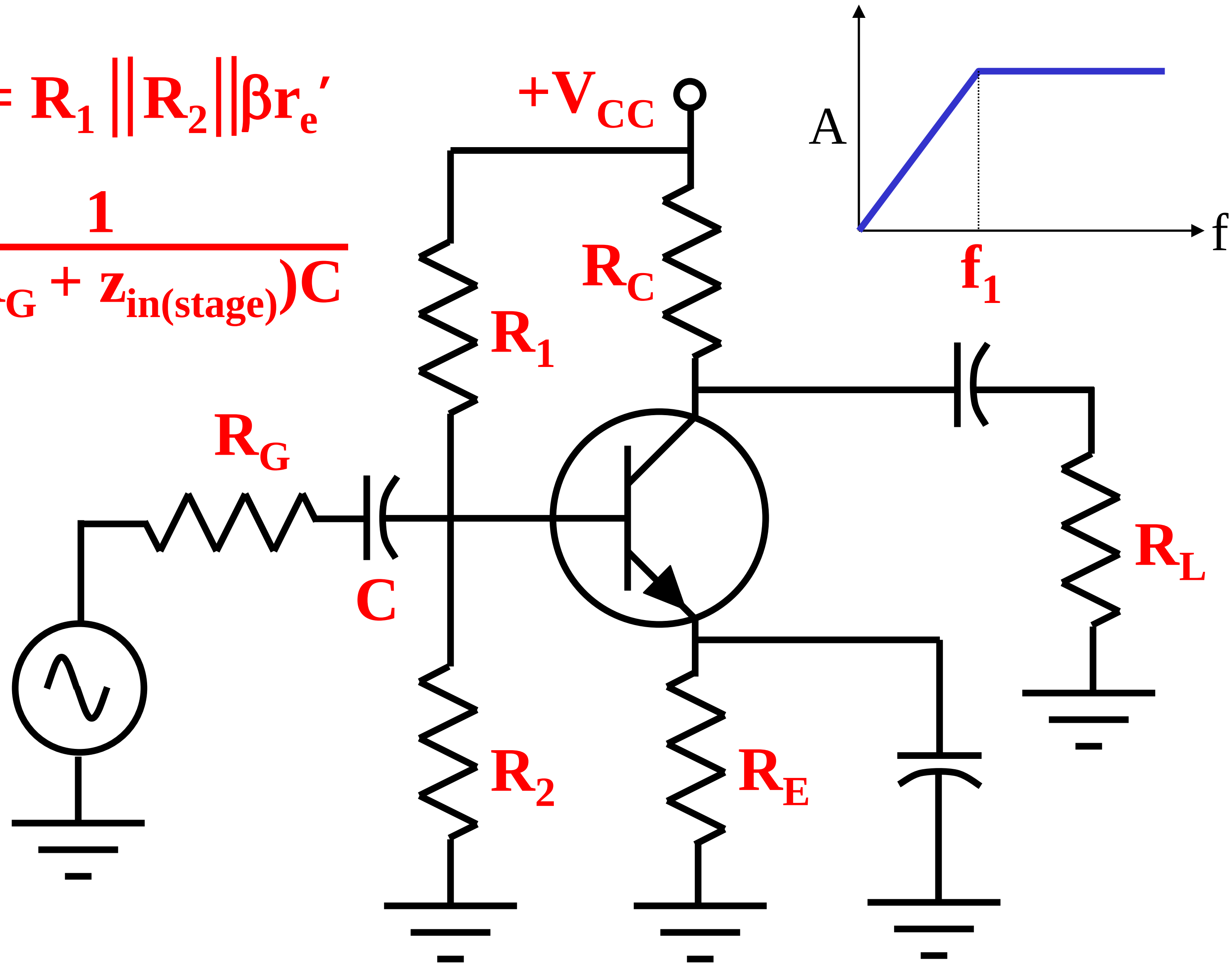
$$f_{cutoff} = \frac{0.35}{T_R}$$



Cutoff frequency of input coupling capacitor

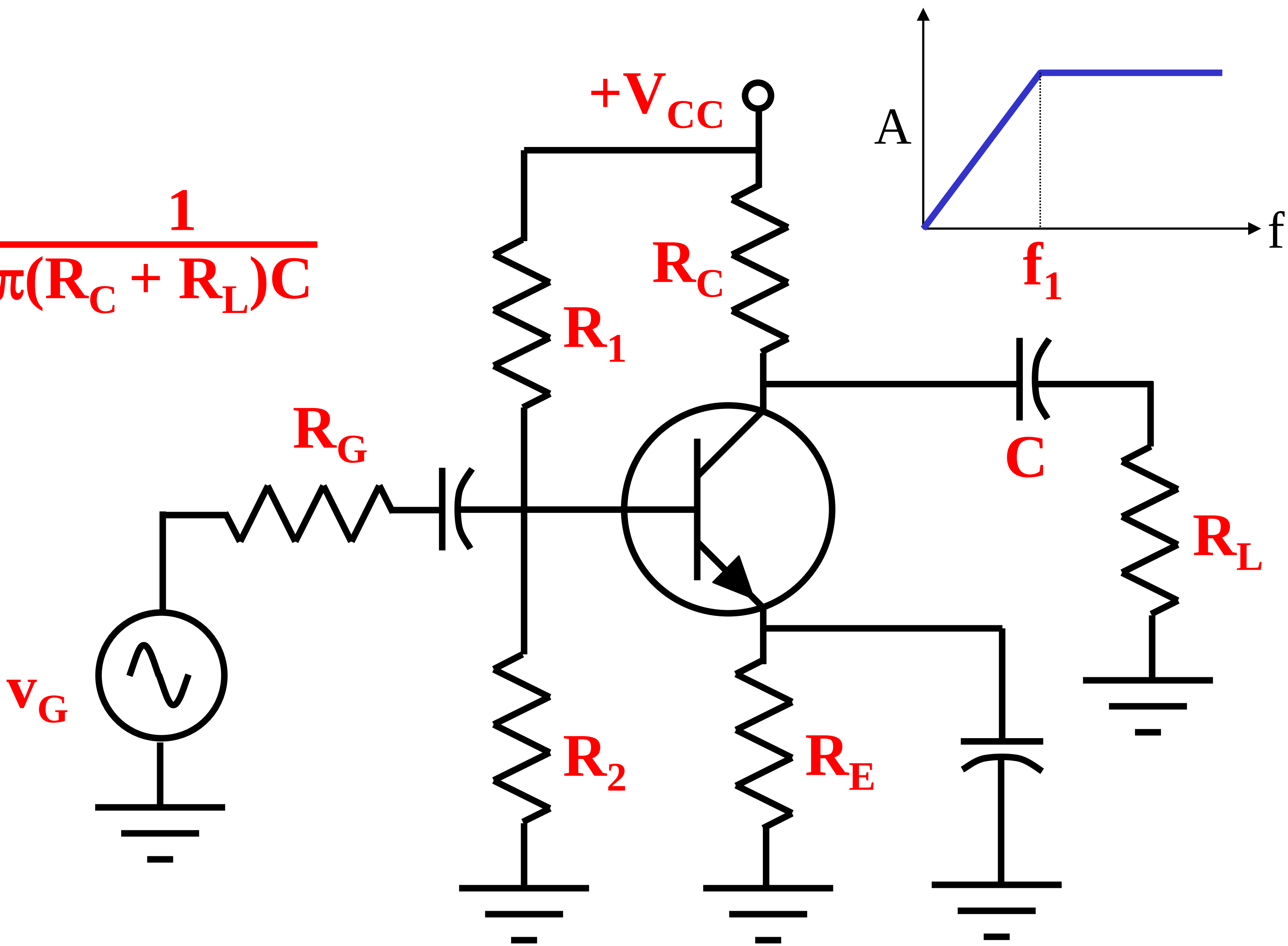
$$z_{in(stage)} = R_1 \| R_2 \| \beta r_e'$$

$$f_1 = \frac{1}{2\pi(R_G + z_{in(stage)})C}$$



Cutoff frequency of output coupling capacitor

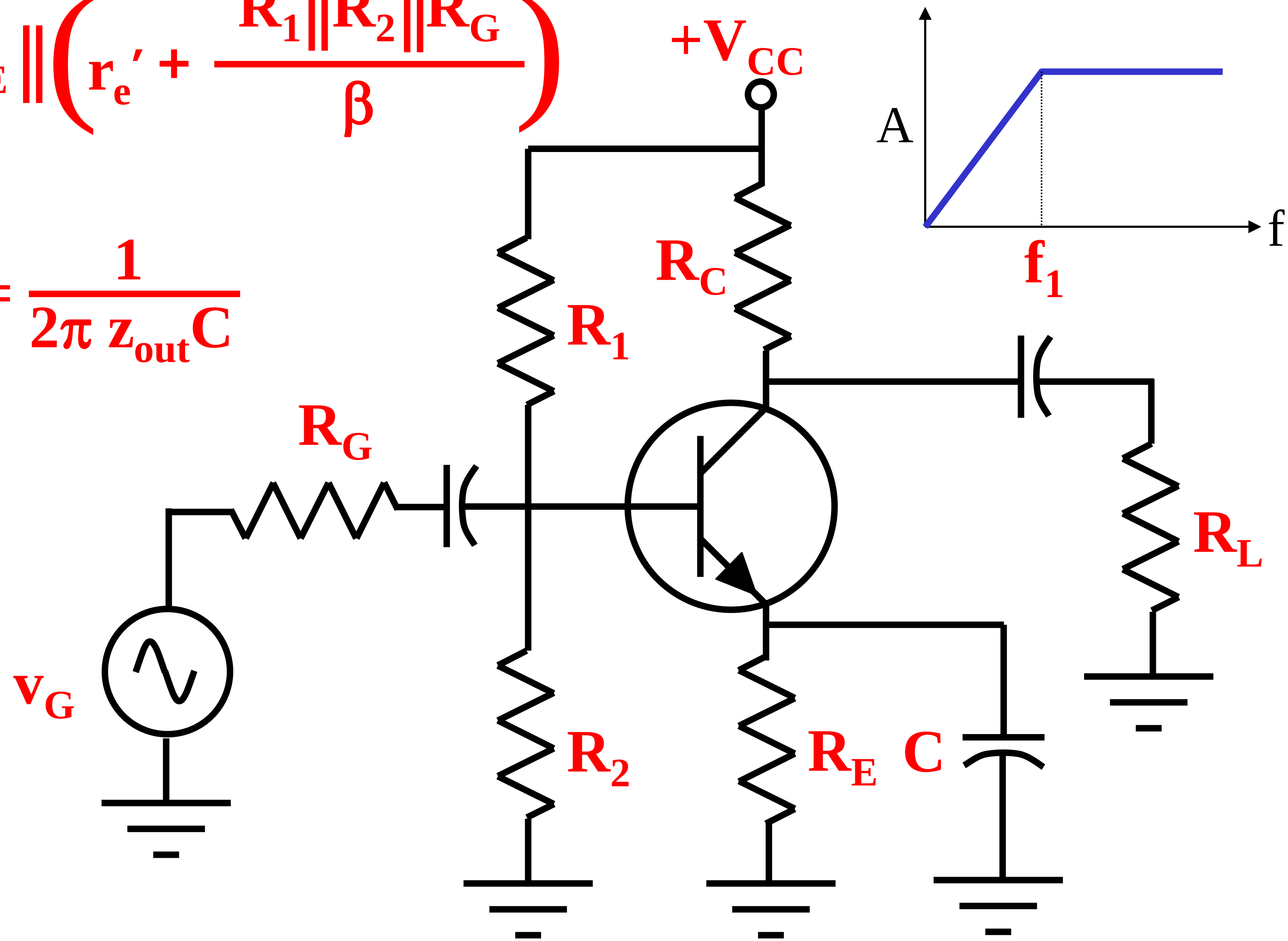
$$f_1 = \frac{1}{2\pi(R_C + R_L)C}$$



Cutoff frequency of emitter bypass capacitor

$$z_{out} = R_E \parallel \left(r_e' + \frac{R_1 \parallel R_2 \parallel R_G}{\beta} \right)$$

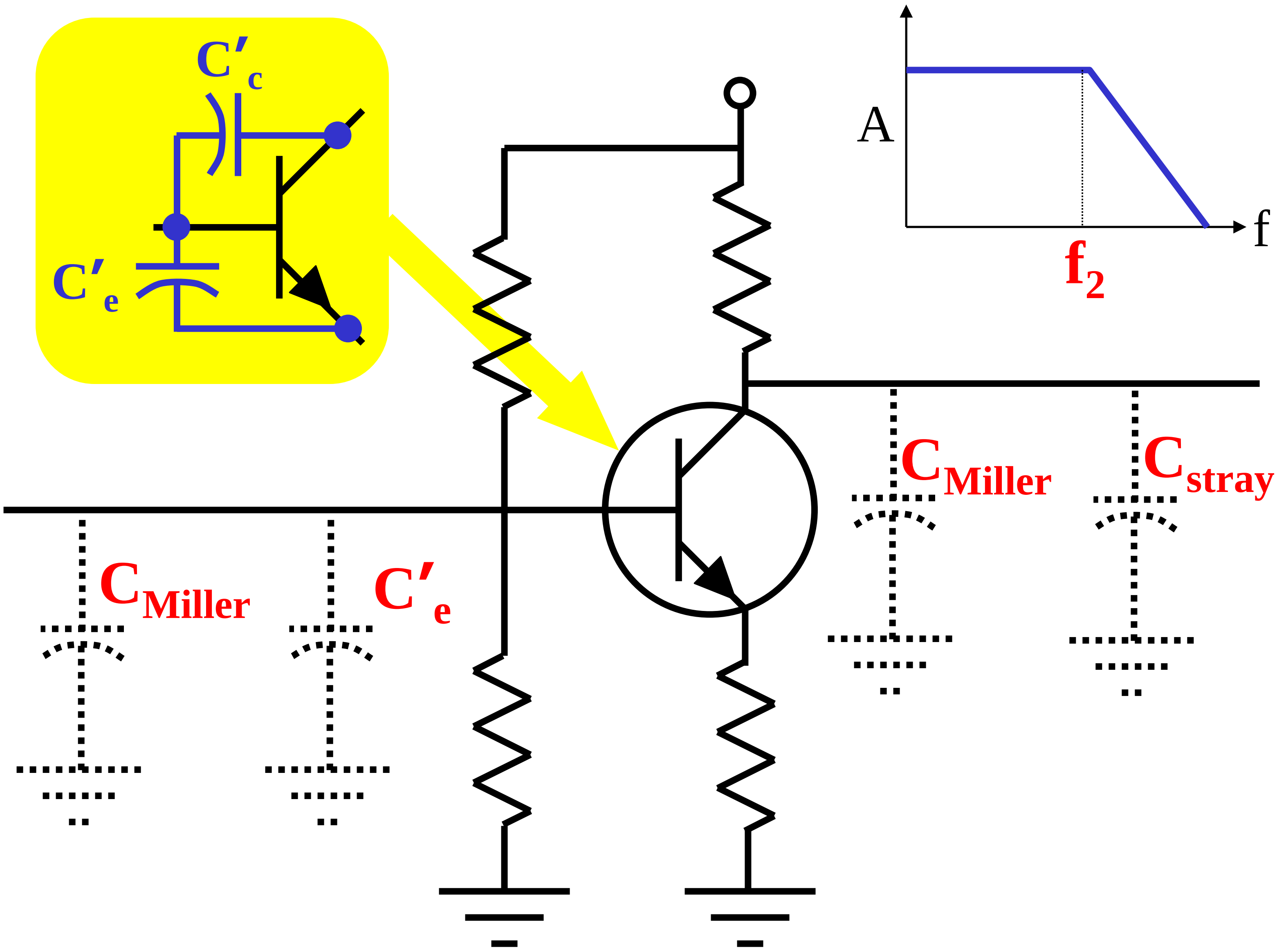
$$f_1 = \frac{1}{2\pi\, z_{out} C}$$



Combined frequency effects

- **The input coupling, output coupling, and emitter bypass capacitors each produce a cutoff frequency.**
- **One is usually dominant (the highest frequency) and produces a rolloff of 20 dB/decade as frequency *decreases*.**
- **When the next cutoff is reached, the gain rolloff increases to 40 dB/decade.**
- **When the third is reached, it becomes 60 dB/decade.**

Base and collector bypass circuits



Bypass circuits

- **The base bypass circuit contains the internal base-emitter capacitance (C'_e) and the Miller capacitance due to the internal collector-base feedback capacitance (C'_c)**
- **The collector bypass circuit contains the Miller capacitance and the stray (wiring) capacitance.**