Frequency Response

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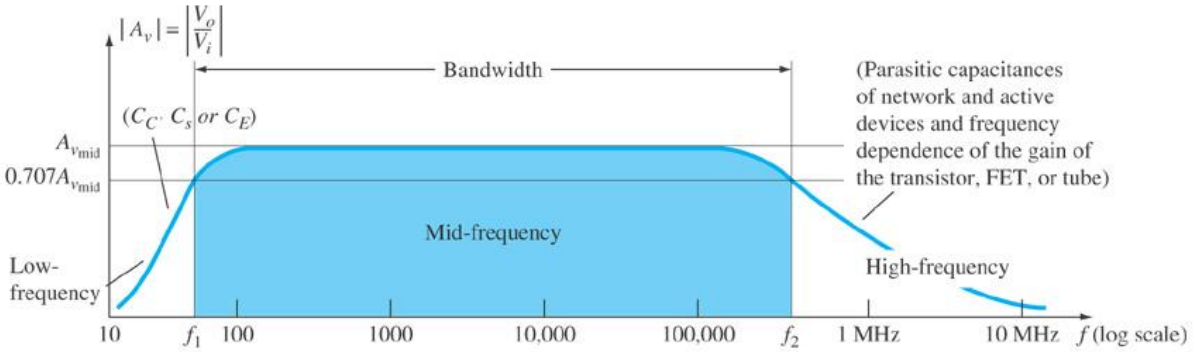
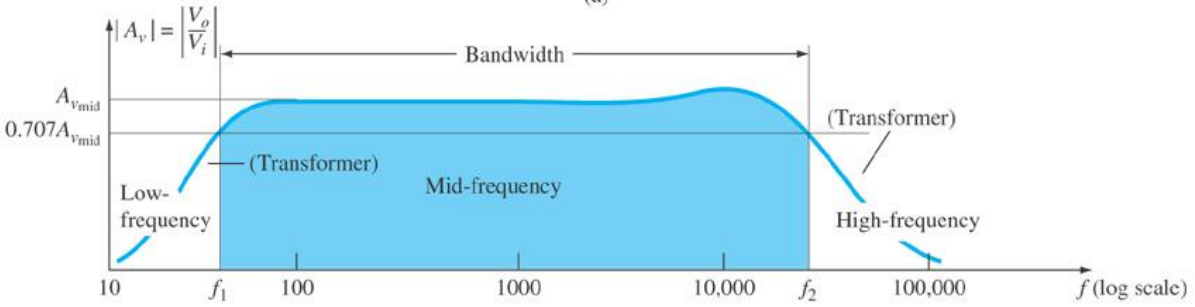
General Frequency Considerations

The **frequency response** of an amplifier refers to the frequency range in which the amplifier will operate with negligible effects from capacitors and capacitance in devices. This range of frequencies can be called the **mid-range**.

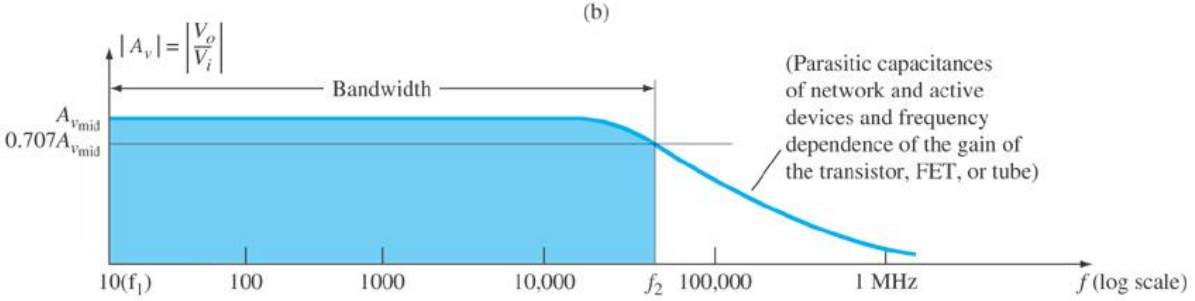
- At frequencies above and below the midrange, capacitance and any inductance will affect the gain of the amplifier.
- At low frequencies the coupling and bypass capacitors lower the gain.
- At high frequencies stray capacitances associated with the active device lower the gain.
- Also, cascading amplifiers limits the gain at high and low frequencies.


$|A_v| = \left|\frac{V_o}{V_i}\right|$
Bandwidth
(Parasitic capacitances of network and active devices and frequency dependence of the gain of the transistor, FET, or tube)
(C_C, C_s, or C_E)
$A_{v_{mid}}$
$0.707A_{v_{mid}}$
Mid-frequency
Low-frequency
High-frequency
10
f_1
100
1000
10,000
100,000
f_2
1 MHz
10 MHz
f (log scale)

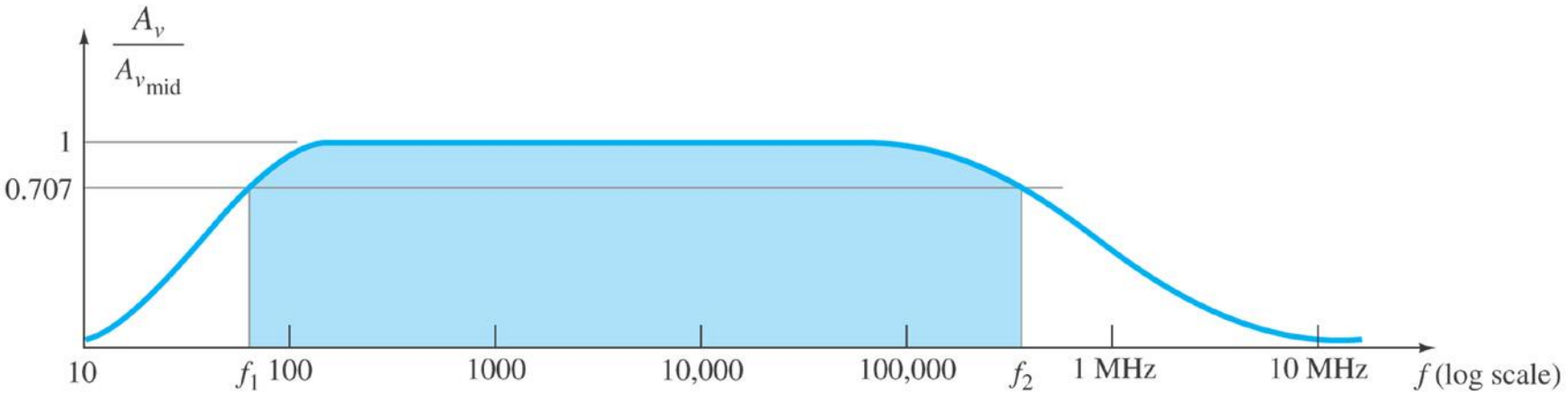
(a)


$|A_v| = \left|\frac{V_o}{V_i}\right|$
Bandwidth
$A_{v_{mid}}$
$0.707A_{v_{mid}}$
(Transformer)
(Transformer)
Mid-frequency
Low-frequency
High-frequency
10
f_1
100
1000
10,000
f_2
100,000
f (log scale)

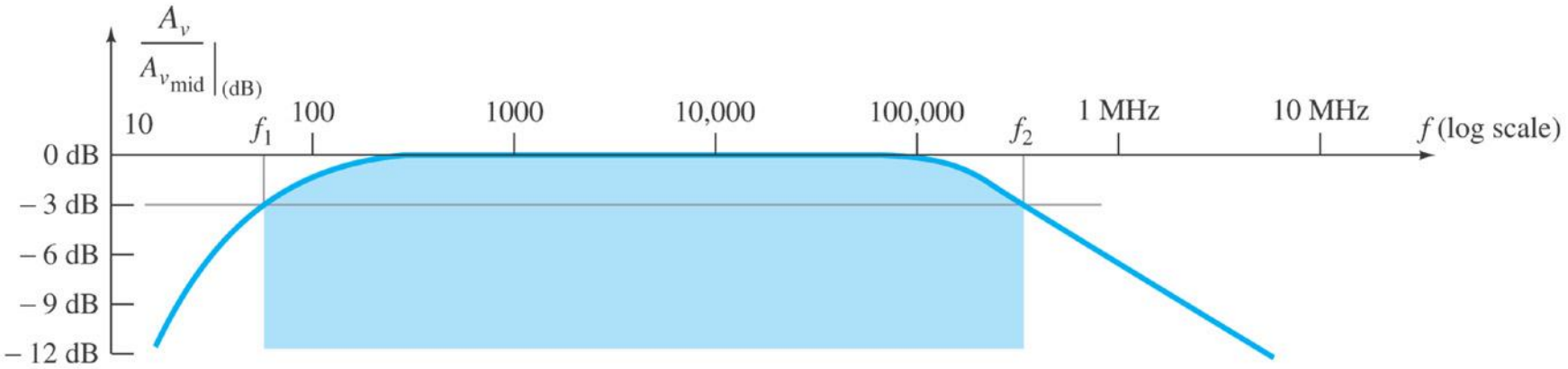
(b)


$|A_v| = \left|\frac{V_o}{V_i}\right|$
Bandwidth
(Parasitic capacitances of network and active devices and frequency dependence of the gain of the transistor, FET, or tube)
$A_{v_{mid}}$
$0.707A_{v_{mid}}$
10(f_1)
100
1000
10,000
f_2
100,000
1 MHz
f (log scale)

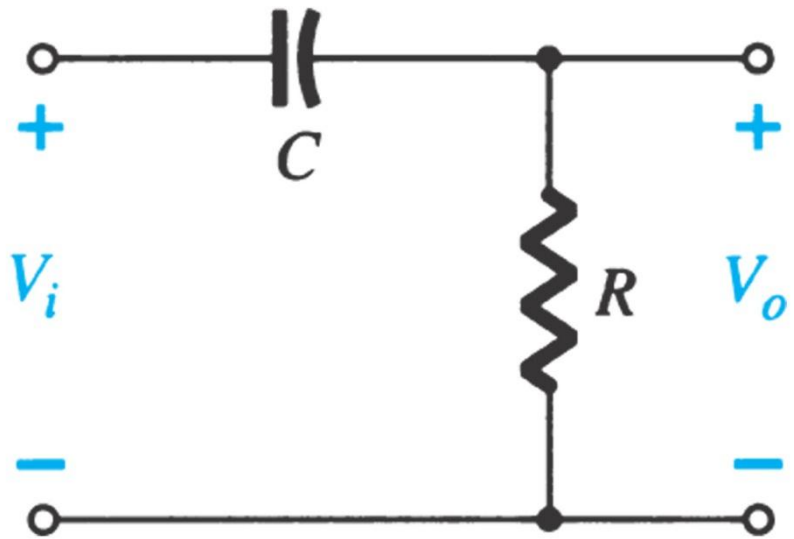
(c)

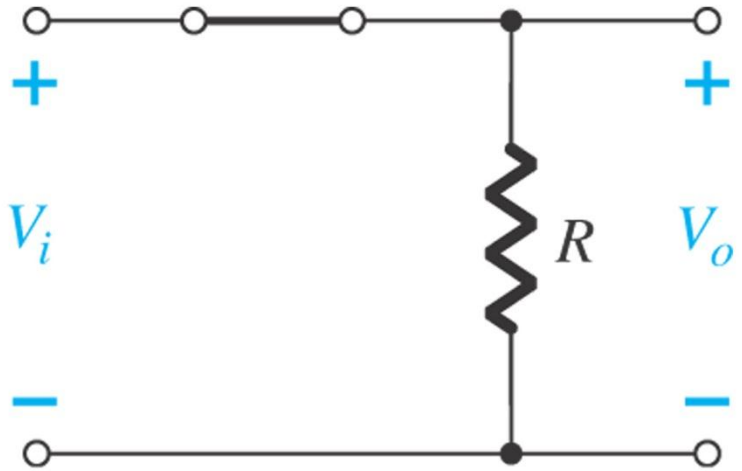


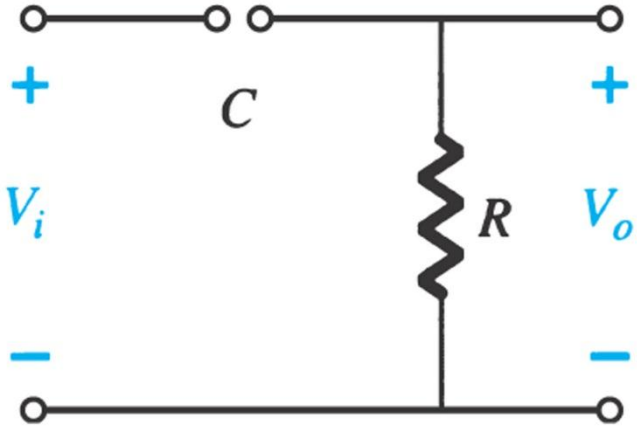
Normalized gain versus frequency plot



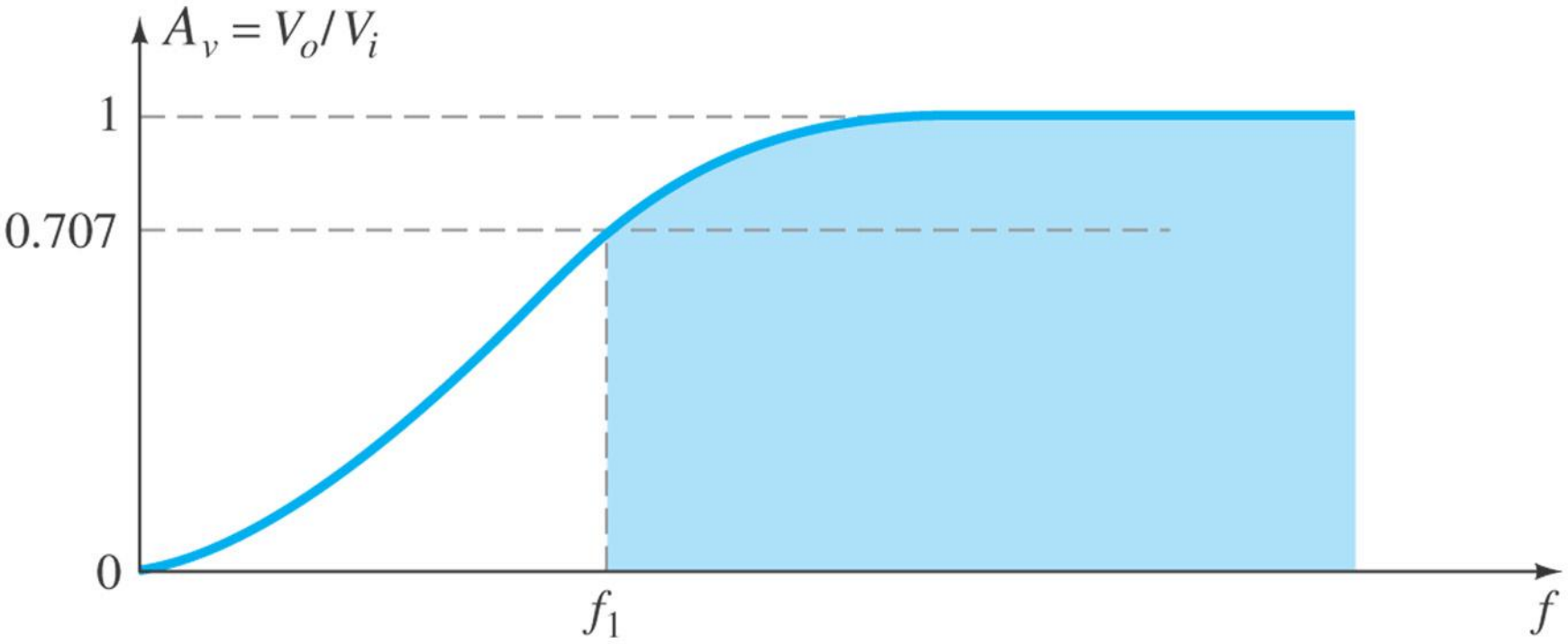
Decibel plot of the normalized gain versus frequency plot



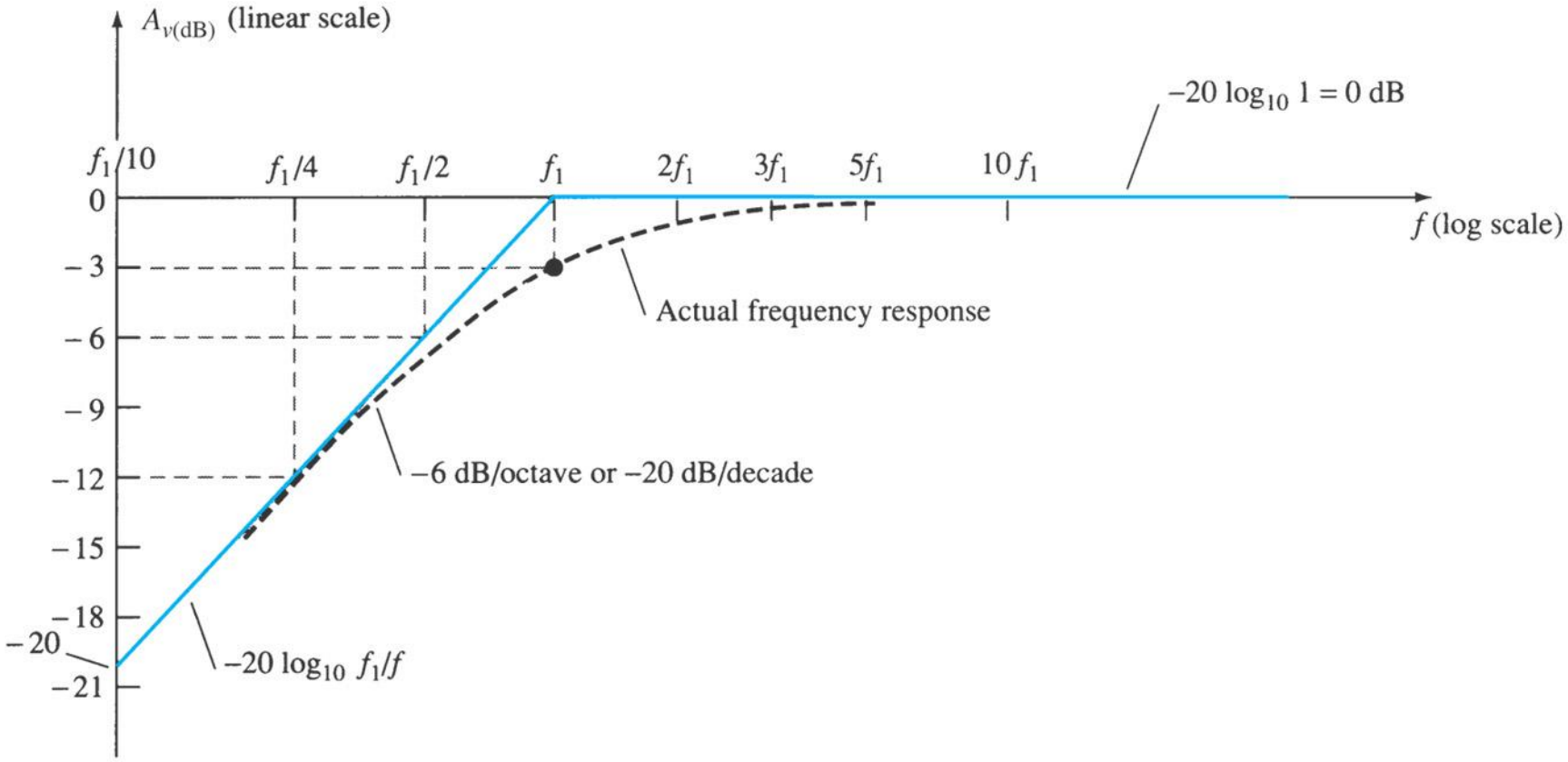




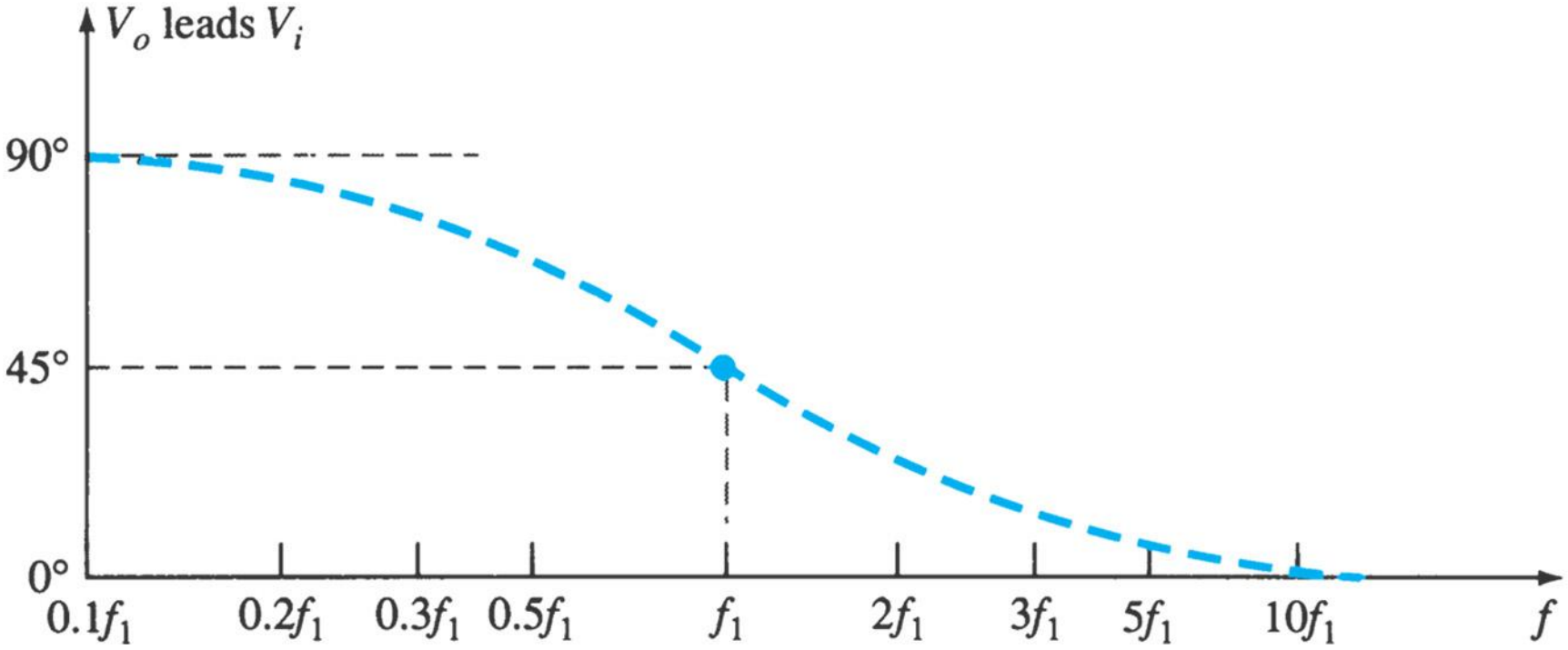
$$A_v = \frac{V_o}{V_i} = \frac{R}{R + X_C}$$



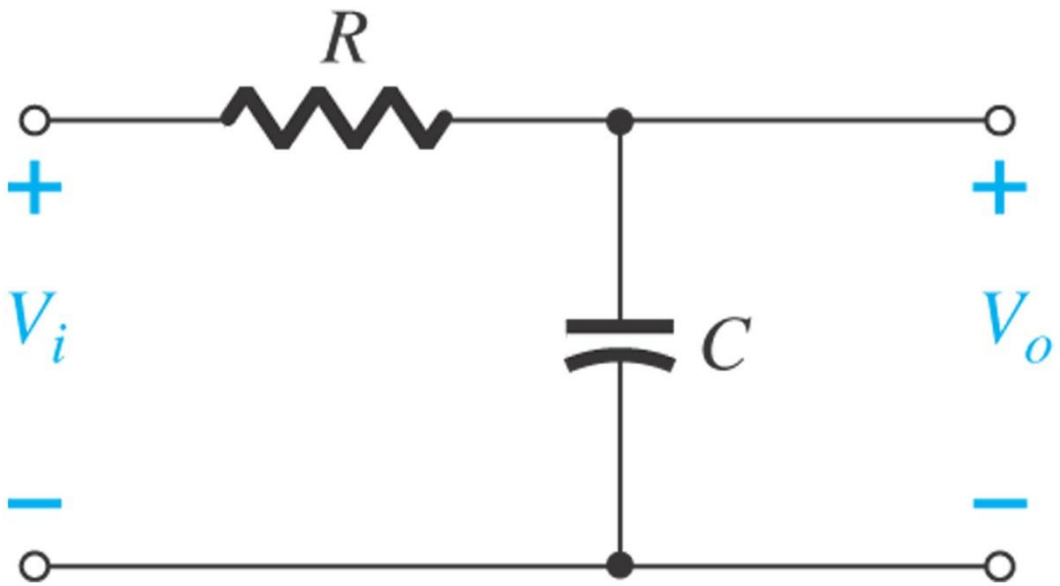
Low-frequency response for the RC circuit of



Bode plot for the low-frequency region.



Phase response for the RC circuit


R
+
V_i
−
C
+
V_o
−

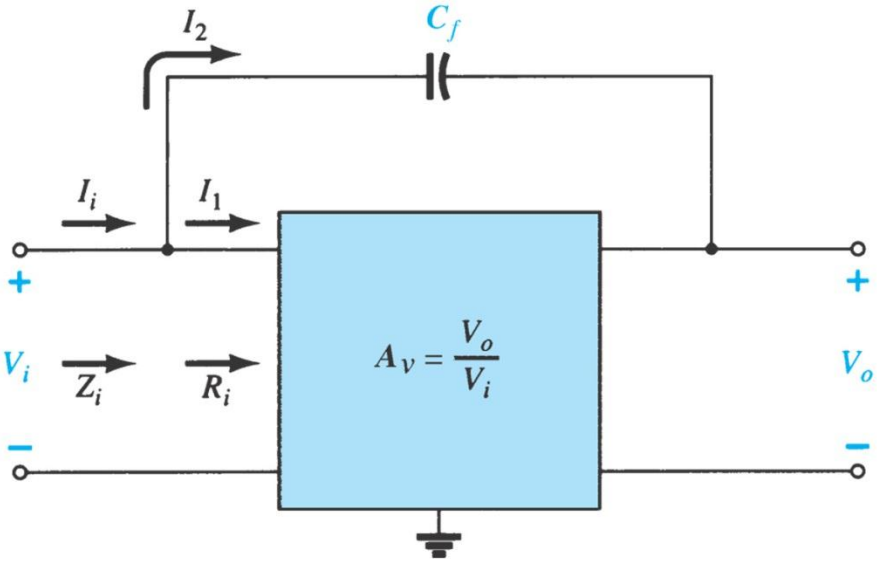
Miller Effect Capacitance

Any *p-n* junction can develop capacitance. This was mentioned in the chapter on diodes.

In a BJT amplifier, this capacitance becomes noticeable between

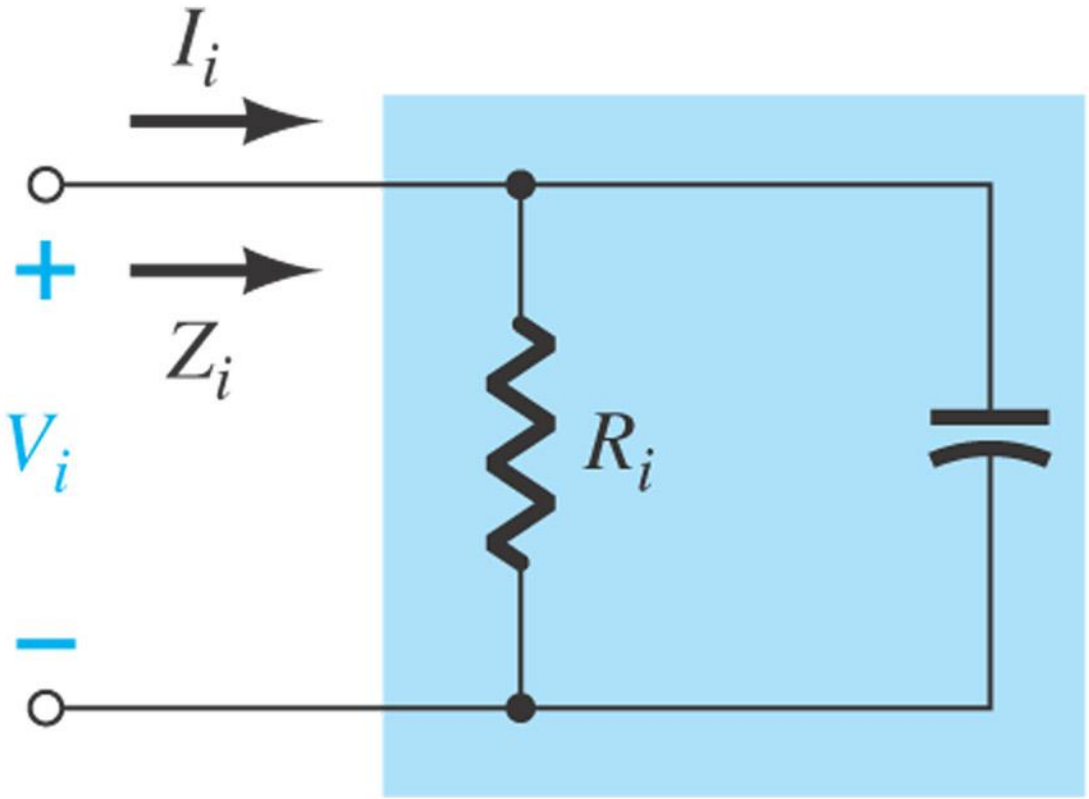
- **The base-collector junction at high frequencies in common-emitter BJT amplifier configurations**
- **The gate-drain junction at high frequencies in common-source FET amplifier configurations.**

It is called the Miller Capacitance, and it affects the input and output circuits.

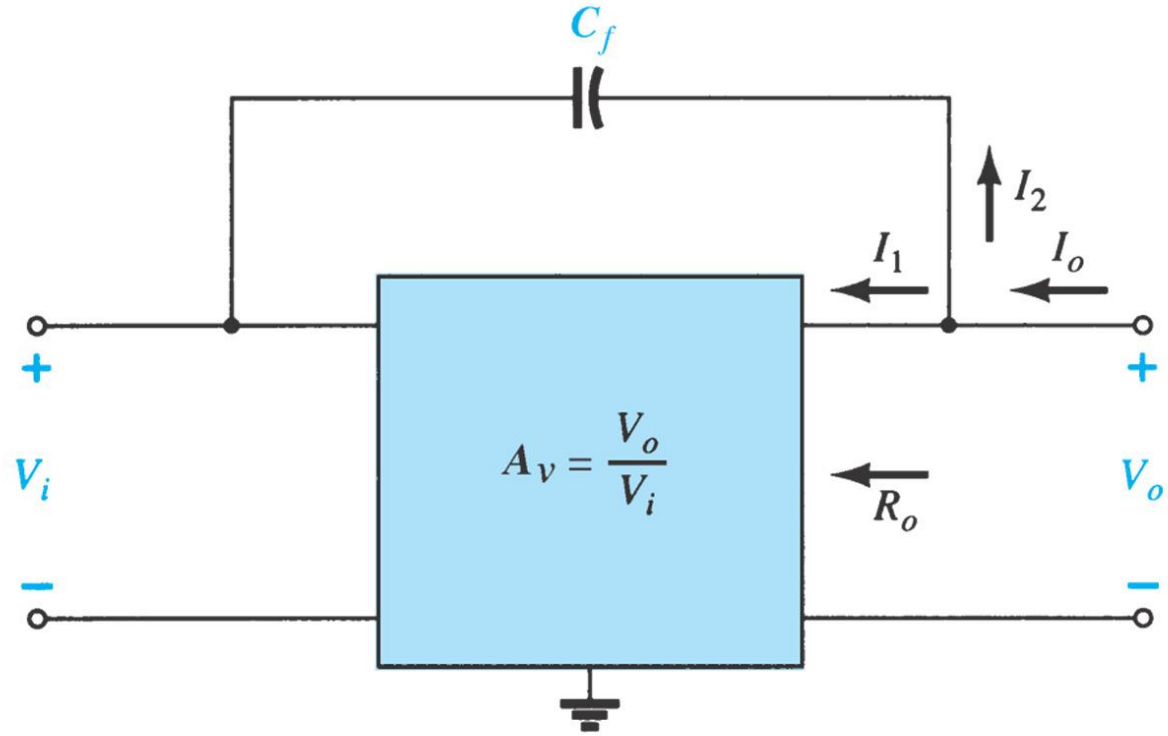


$$C_{Mi} = (1 - A_v)C_f$$

Note that the amount of Miller capacitance is dependent on interelectrode capacitance from input to output (C_f) and the gain (A_v).



$$C_M = (1 - A_\upsilon)\, C_f$$



If the gain (A_v) is considerably greater than 1, then

$$C_{Mo} \cong C_f$$

Capacitances that affect the high-frequency response are

- **Junction capacitances**
  C_{be}, C_{bc}, C_{ce}
- **Wiring capacitances**
  C_{wi}, C_{wo}
- **Coupling capacitors**
  C_S, C_C
- **Bypass capacitor**
  C_E