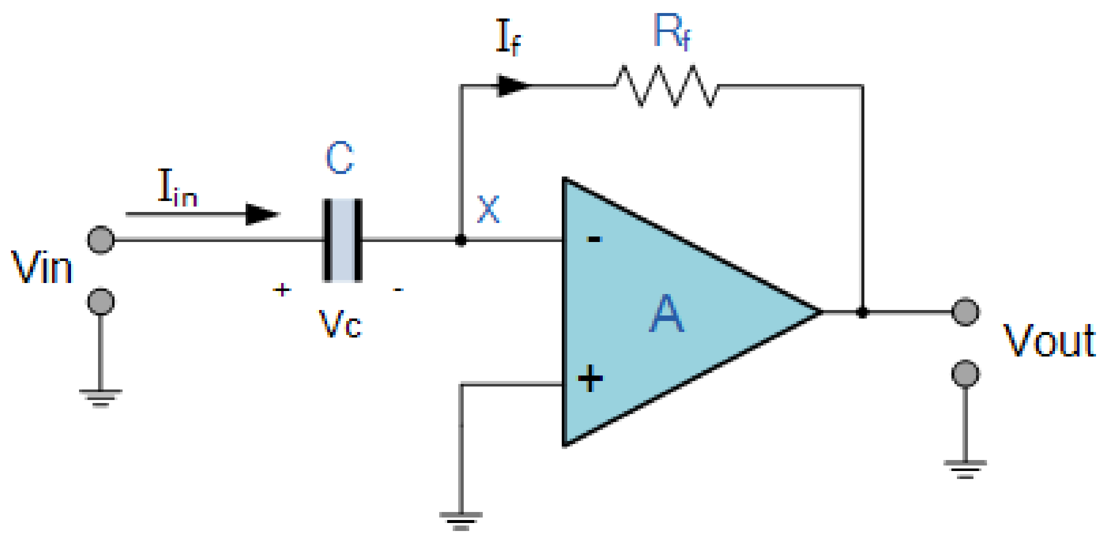
Basic Electronic Circuits
(IEC-103)

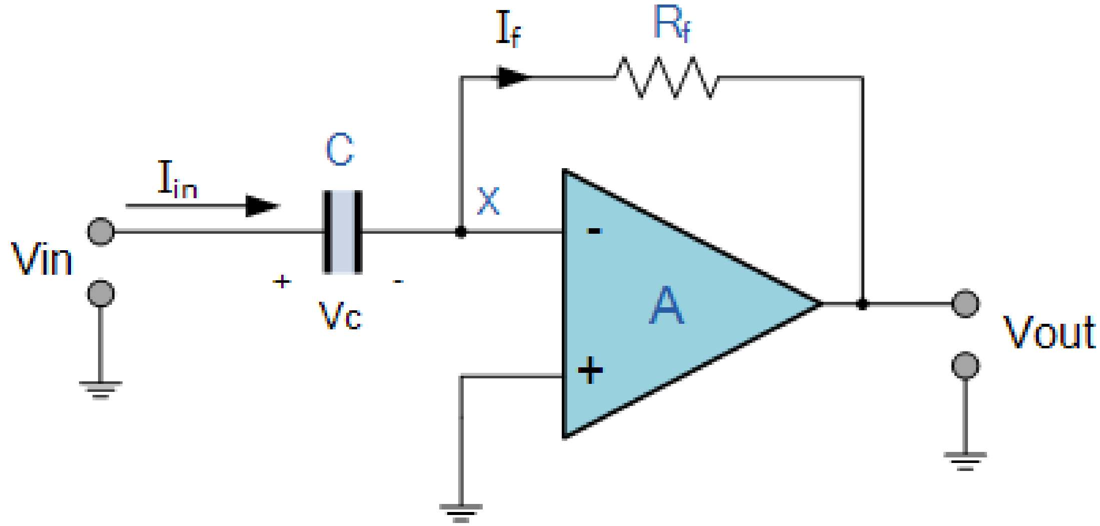
Lecture-06

Op-Amp Circuits

Example

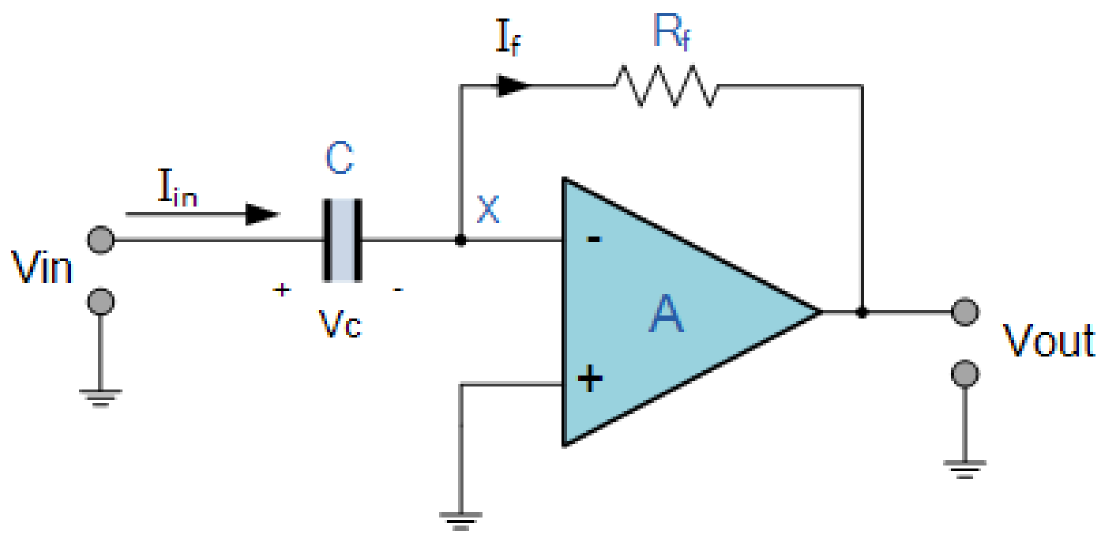


Example (Continued)



$$V_{out} = -R_f C \frac{dV_{in}}{dt}$$

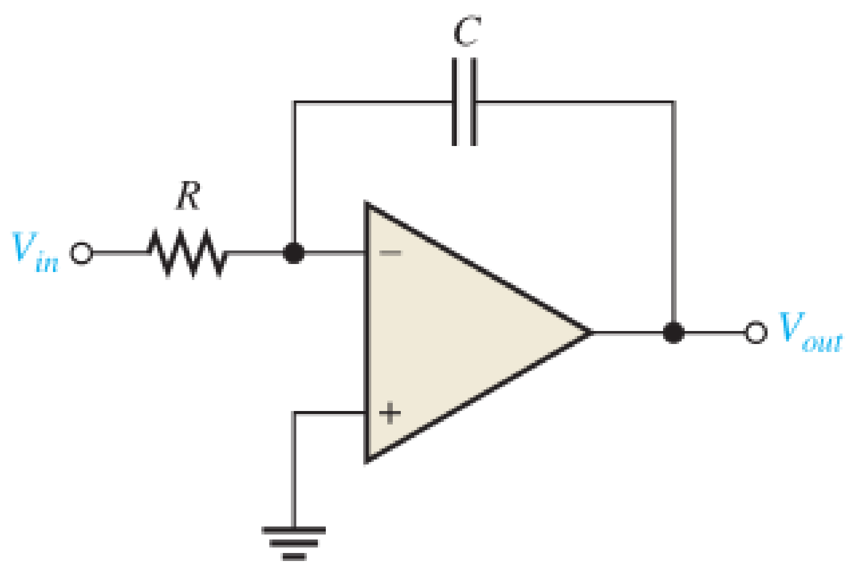
Example (Continued)



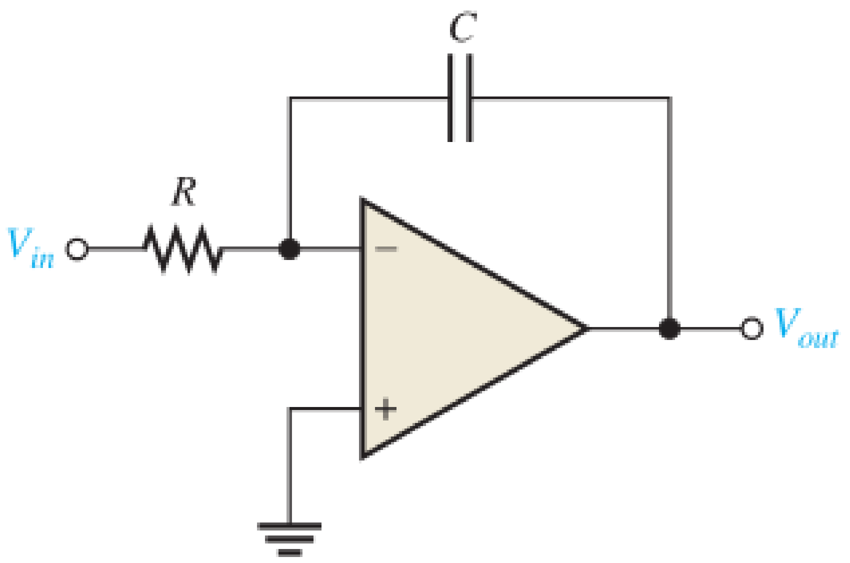
$$V_{out} = -R_f C \frac{dV_{in}}{dt}$$

Differentiator

Example

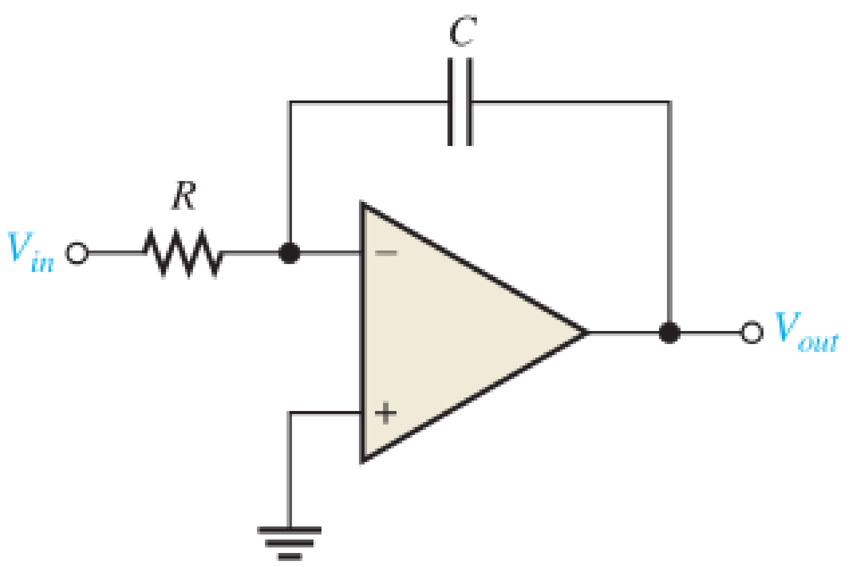


Example (Continued)



$$V_{out} = -\frac{1}{RC}\int V_{in}\,dt$$

Example (Continued)



$$V_{out} = -\frac{1}{RC}\int V_{in}\,dt$$

Integrator

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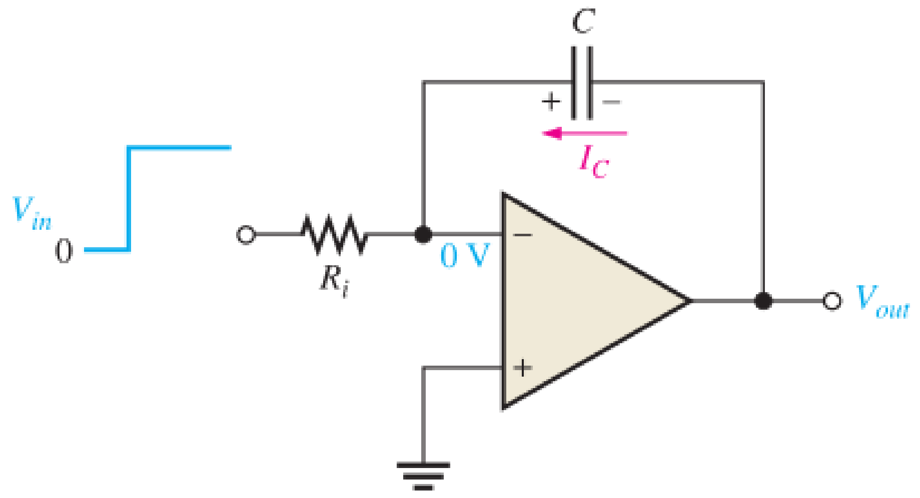

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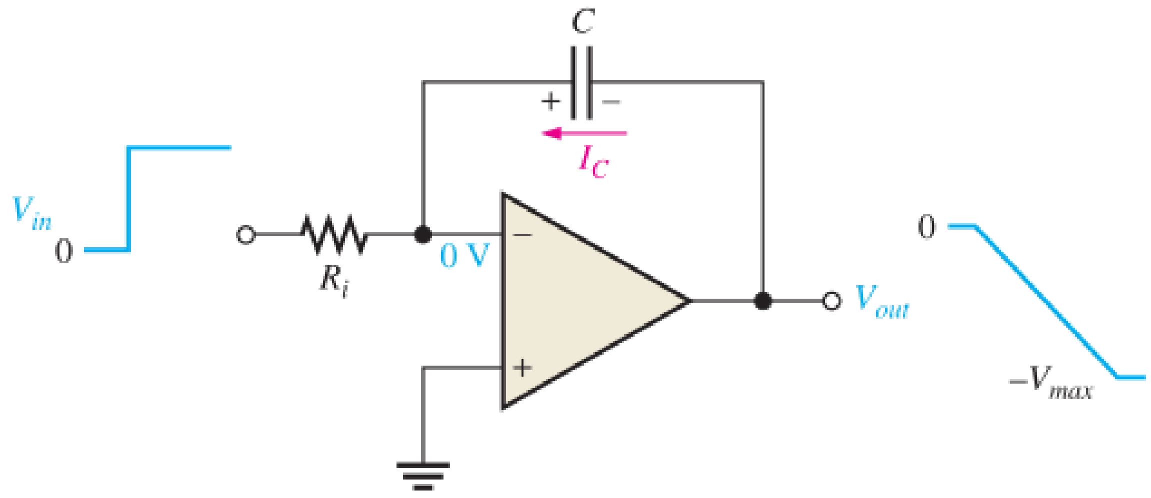
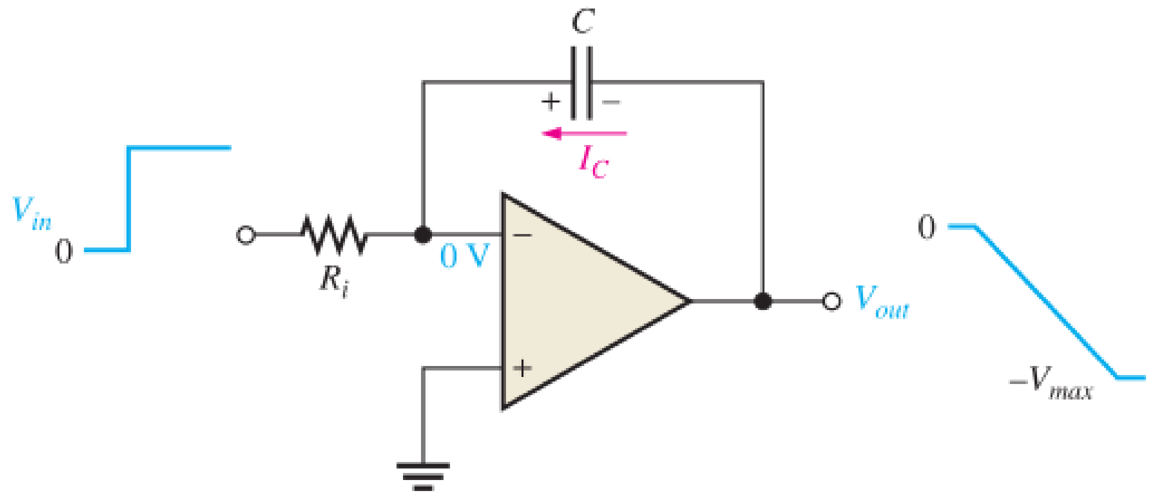


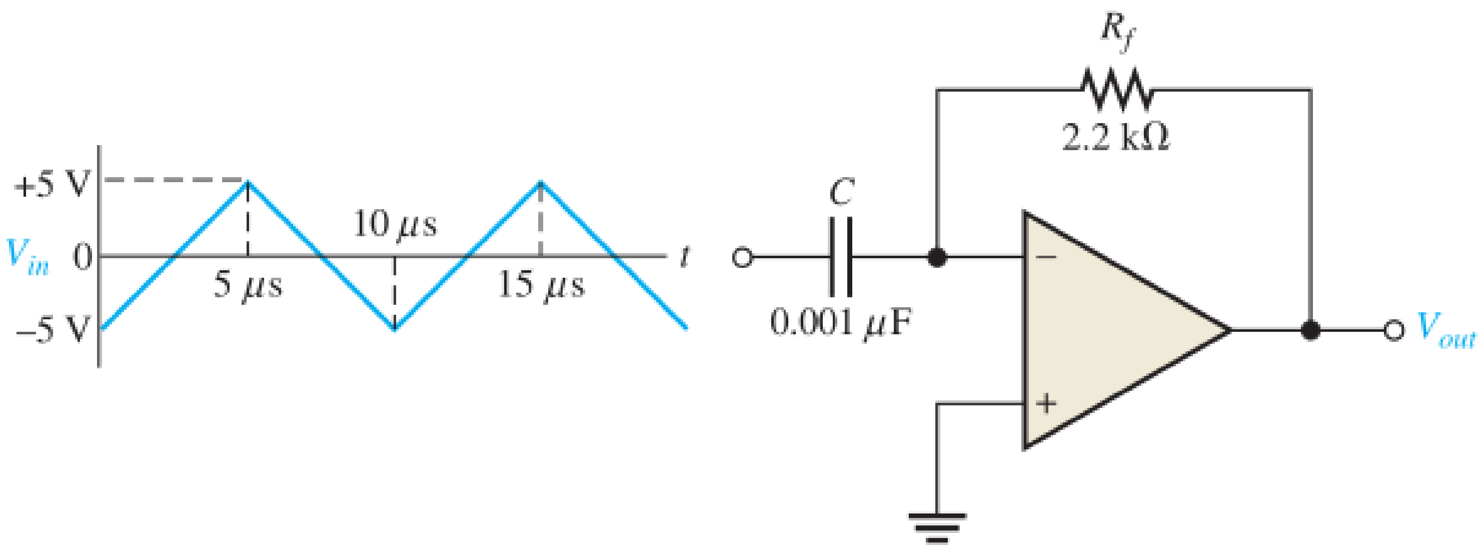
Integrator



A constant input voltage produces a ramp on the output of the integrator before it saturates.

Example

Determine the output voltage of the op-amp ckt.



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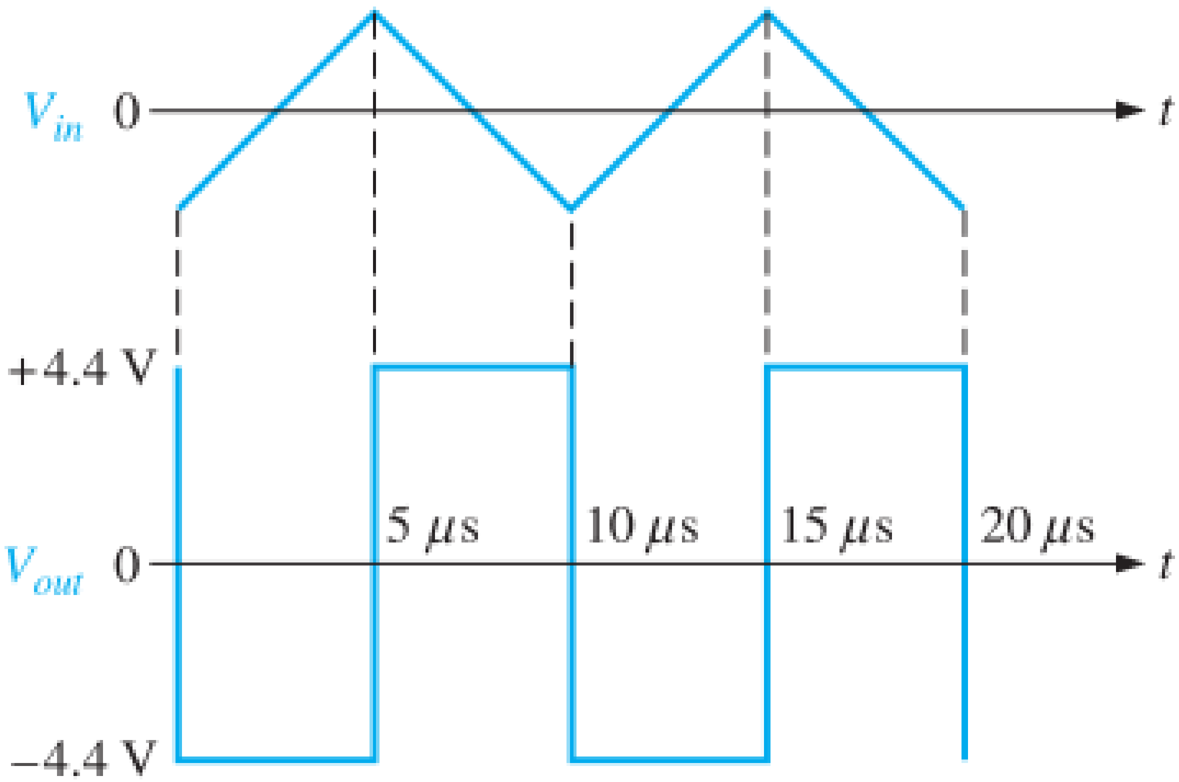
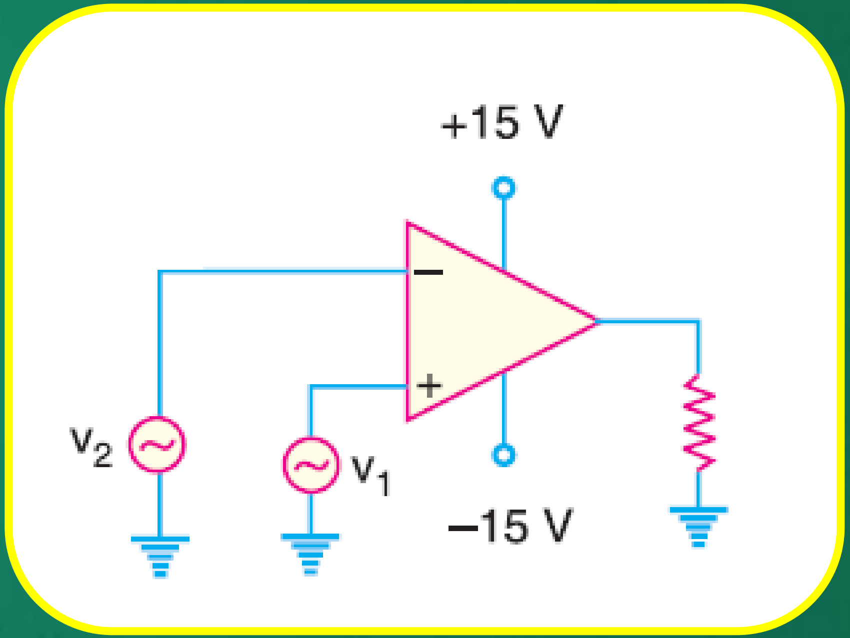
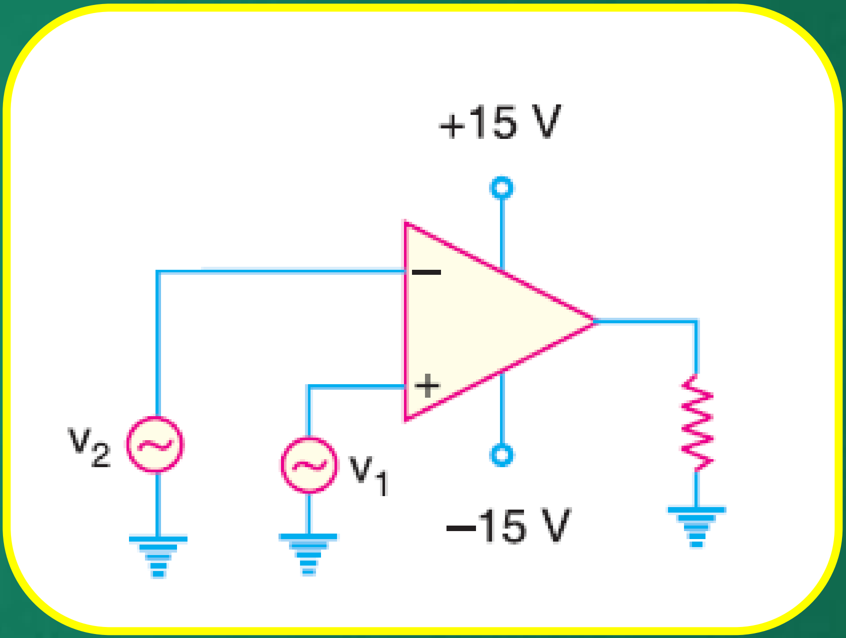


Non-linear Applications

Comparators

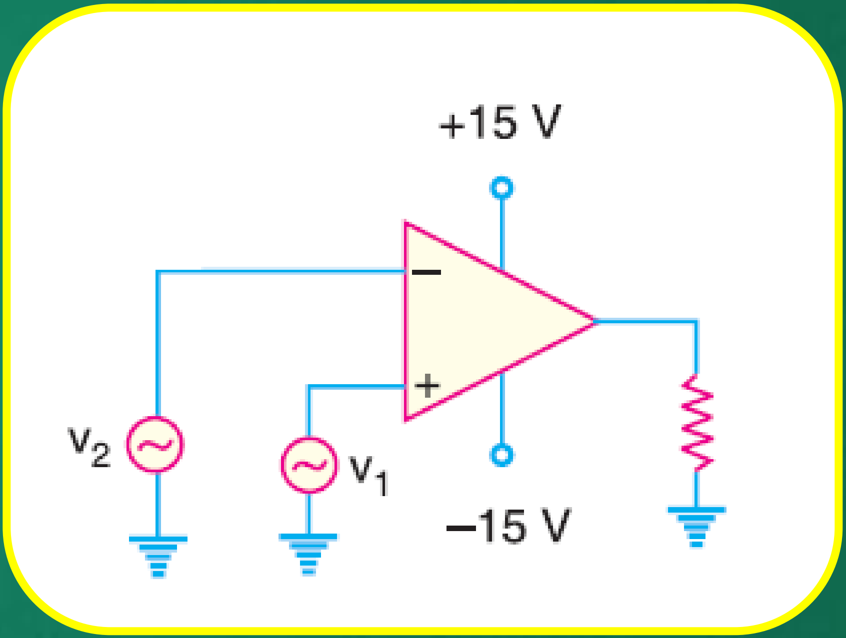


Comparators



- A comparator is an op-amp circuit without negative feedback and takes the advantage of very high open-loop gain.

Comparators



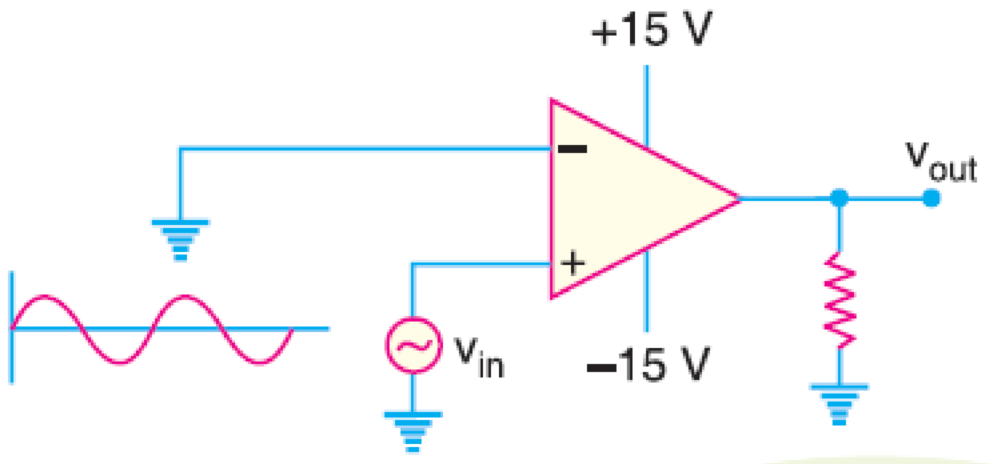
- A comparator is an op-amp circuit without negative feedback and takes the advantage of very high open-loop gain.
- It is operated in a non-linear mode.

Comparators

$$+V_{sat} = +V_{\text{supply}} - 2 = 15 - 2 = +13\ \text{V}$$

$$-V_{sat} = -V_{\text{supply}} + 2 = -15 + 2 = -13\ \text{V}$$

Comparator (Square Wave Generator)



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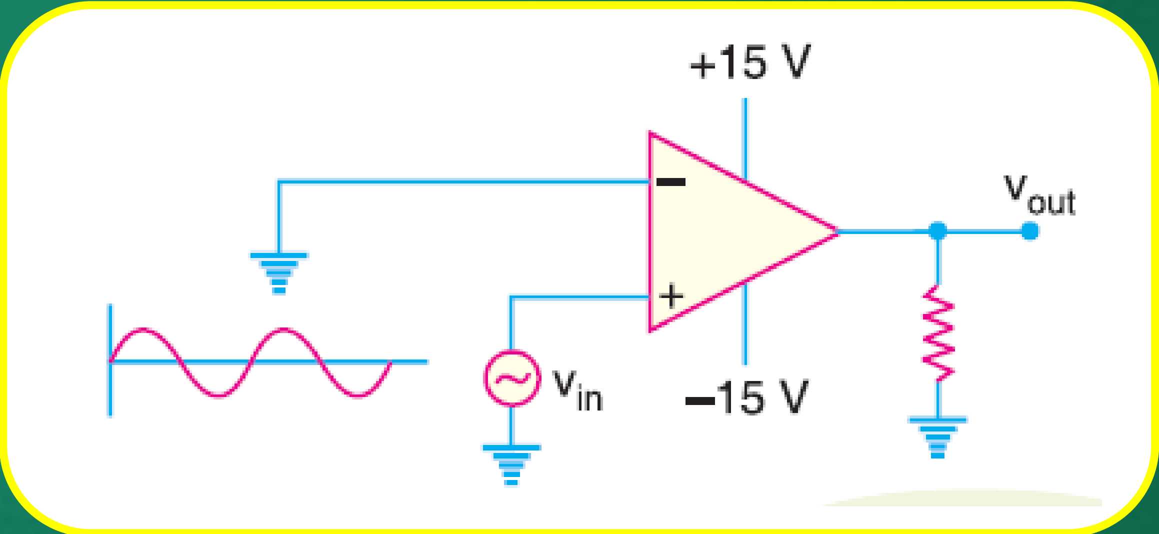
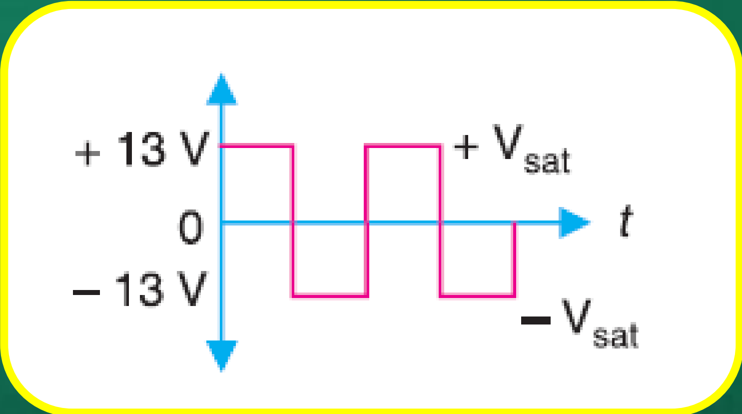
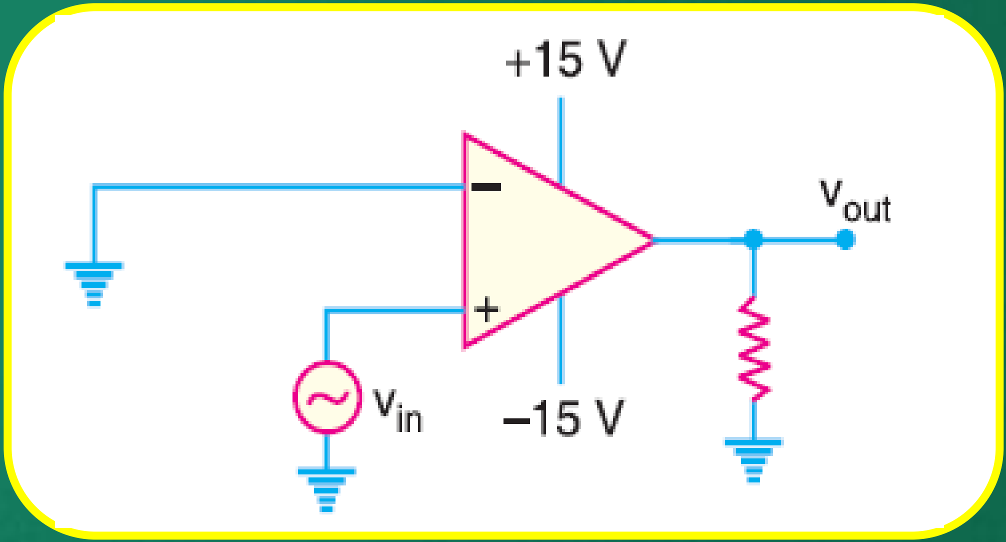




Comparator
(Zero Crossing Detector)



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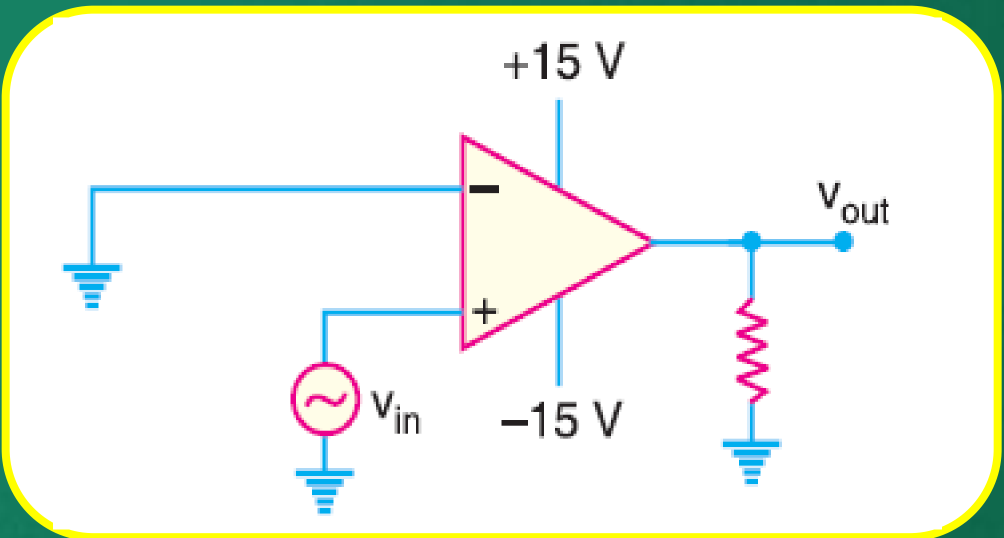
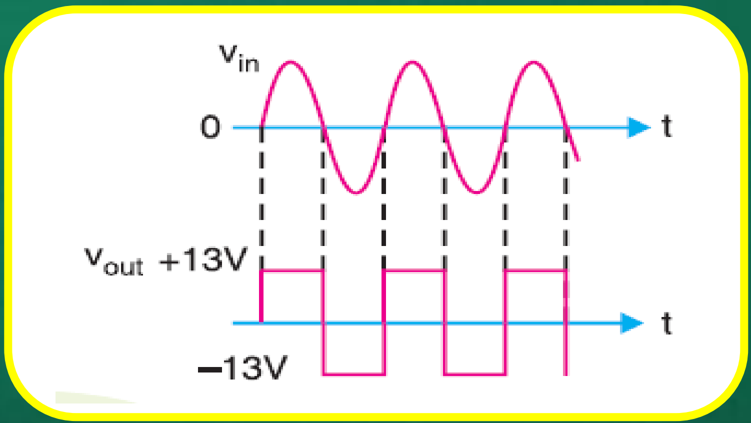
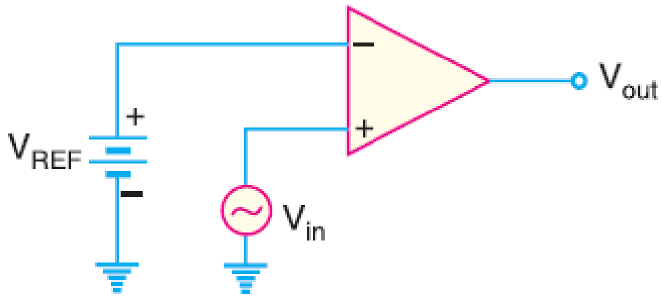


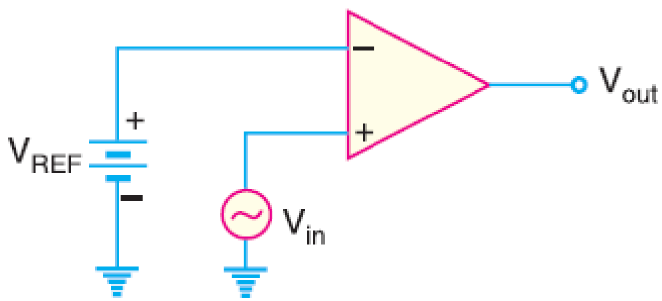


Comparator
(Level Detector)



(*i*) Battery reference

Comparator
(Level Detector)



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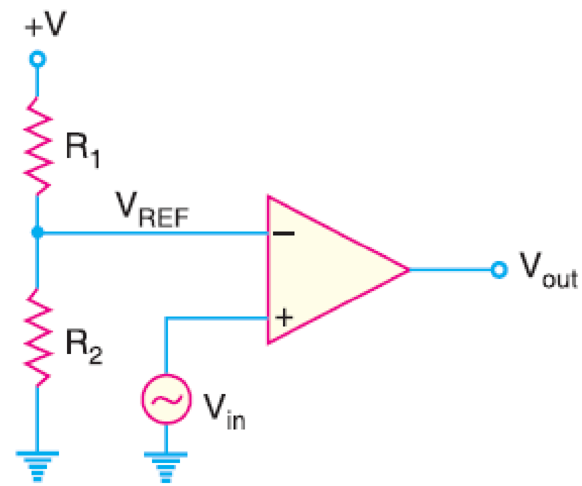
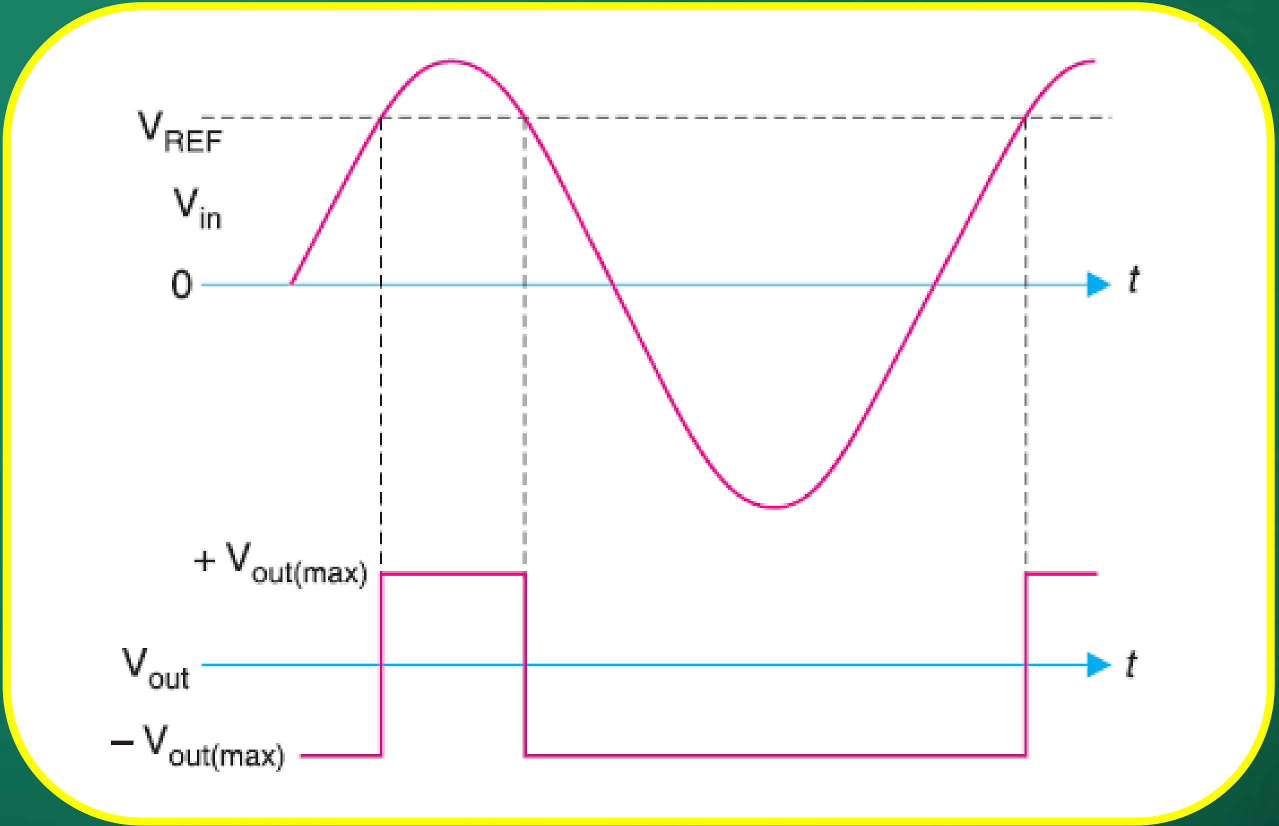


(*ii*) Voltage-divider reference

Comparator (Level Detector)



Feedback

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- 2 types of feedback: regenerative (+ve feedback) degenerative (-ve feedback).
- Unless we want your circuit to oscillate, we use NEGATIVE FEEDBACK.
- This idea negative feedback was first used in the late 1920's when building amplifiers with certain gain was difficult.
- Harold Black invented negative feedback.

Properties of Feedback

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- The bandwidth of an amplifier can be extended.

Implementation of Feedback

- Portion of output is fed back to the inverting terminal of the amplifier.

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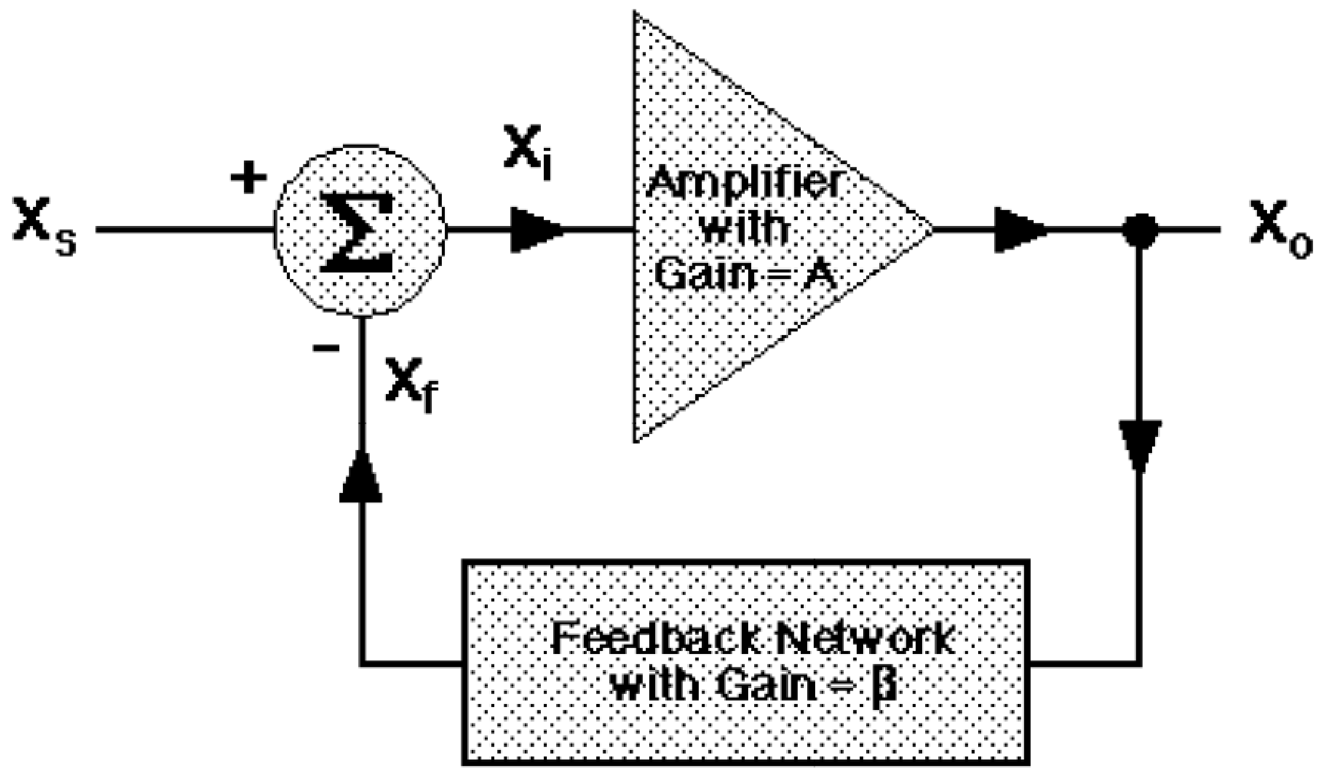
- If we use negative feedback, overall gain of the amplifier is always less than the maximum achievable by the amplifier without feedback.

Basic Block Diagram



Closed Loop Gain

$$A_f \equiv \frac{x_o}{x_s} = \frac{A}{1 + A\beta} \approx \frac{1}{\beta} \quad \text{(for very large A)}$$

Closed Loop Bandwidth

Open loop gain

$$A(s) = \frac{A_0}{1 + \frac{s}{\omega_H}}$$

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Closed Loop Bandwidth

Open loop gain

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If we use amplifier with negative feedback

$$A_f(s) = \frac{A(s)}{1 + \beta A(s)}$$

Closed Loop Bandwidth

$$A_f(s) = \frac{\dfrac{A_0}{1+\beta A_0}}{1+\dfrac{s}{\omega_H(1+\beta A_0)}}$$

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$$A_f(s) = \frac{\dfrac{A_0}{1+\beta A_0}}{1+\dfrac{s}{\omega_H(1+\beta A_0)}} = \frac{A_{0f}}{1+\dfrac{s}{\omega_{Hf}}}$$

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$$\omega_{Hf} = \omega_H(1+\beta A_0)$$

$$A_{0f} = \frac{A_0}{(1+\beta A_0)}$$

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where

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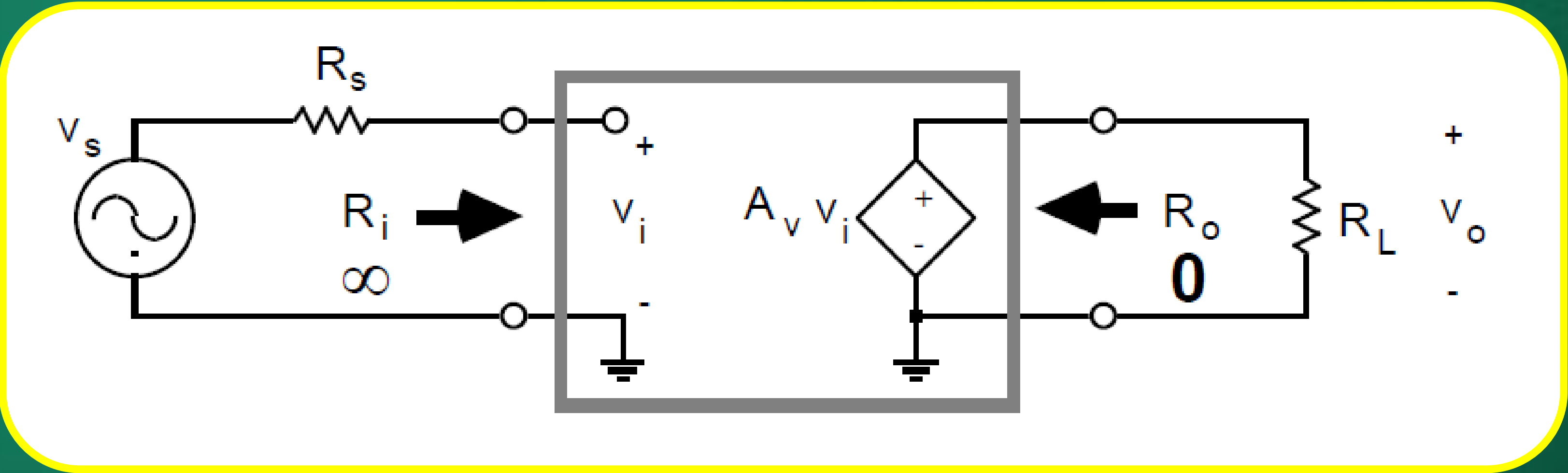
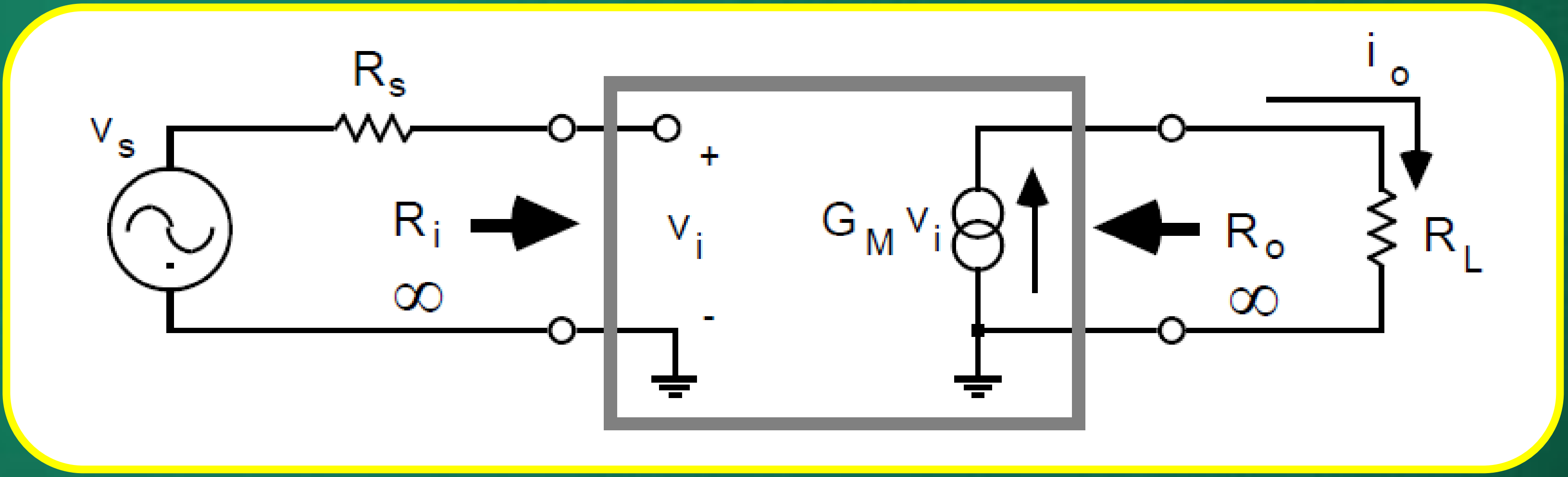
The cut-off frequency is increased by a factor $(1+A_0\beta)$

Types of Amplifiers

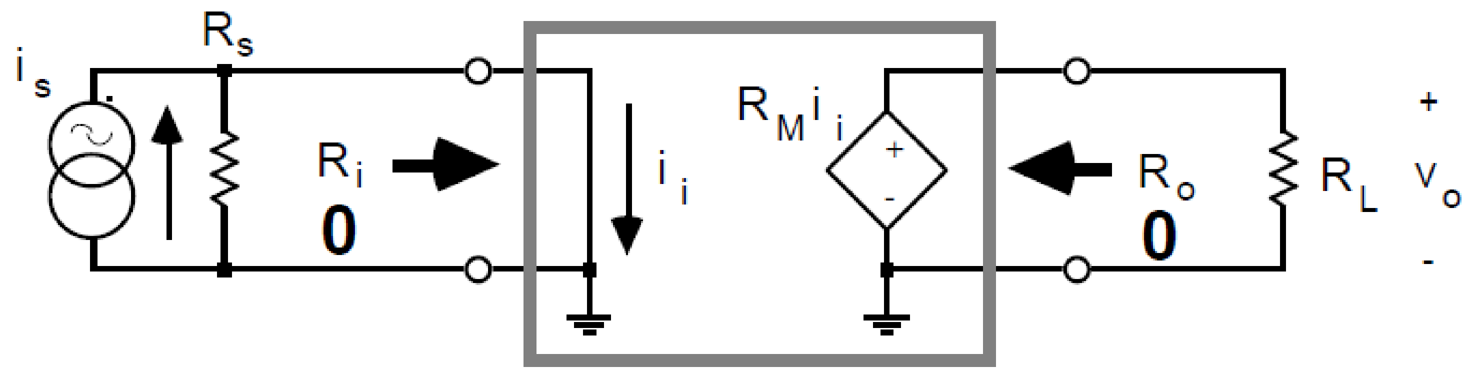
Ideal Voltage Amplifier



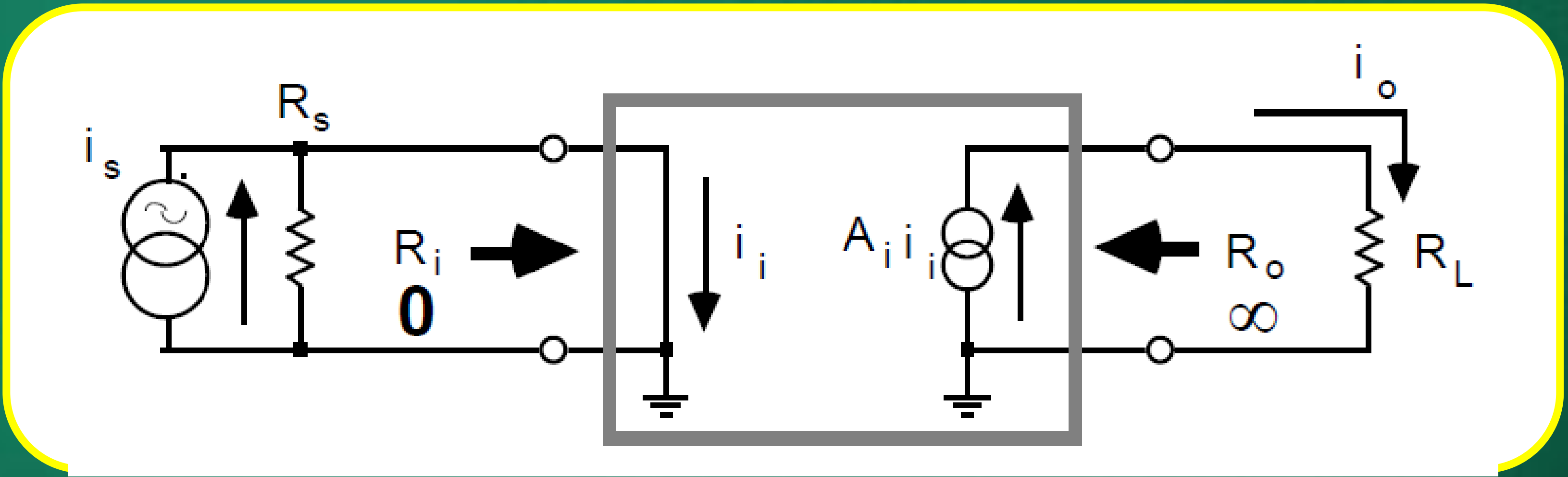
Ideal Transconductance Amplifier



Ideal Transresistance Amplifier



Ideal Current Amplifier

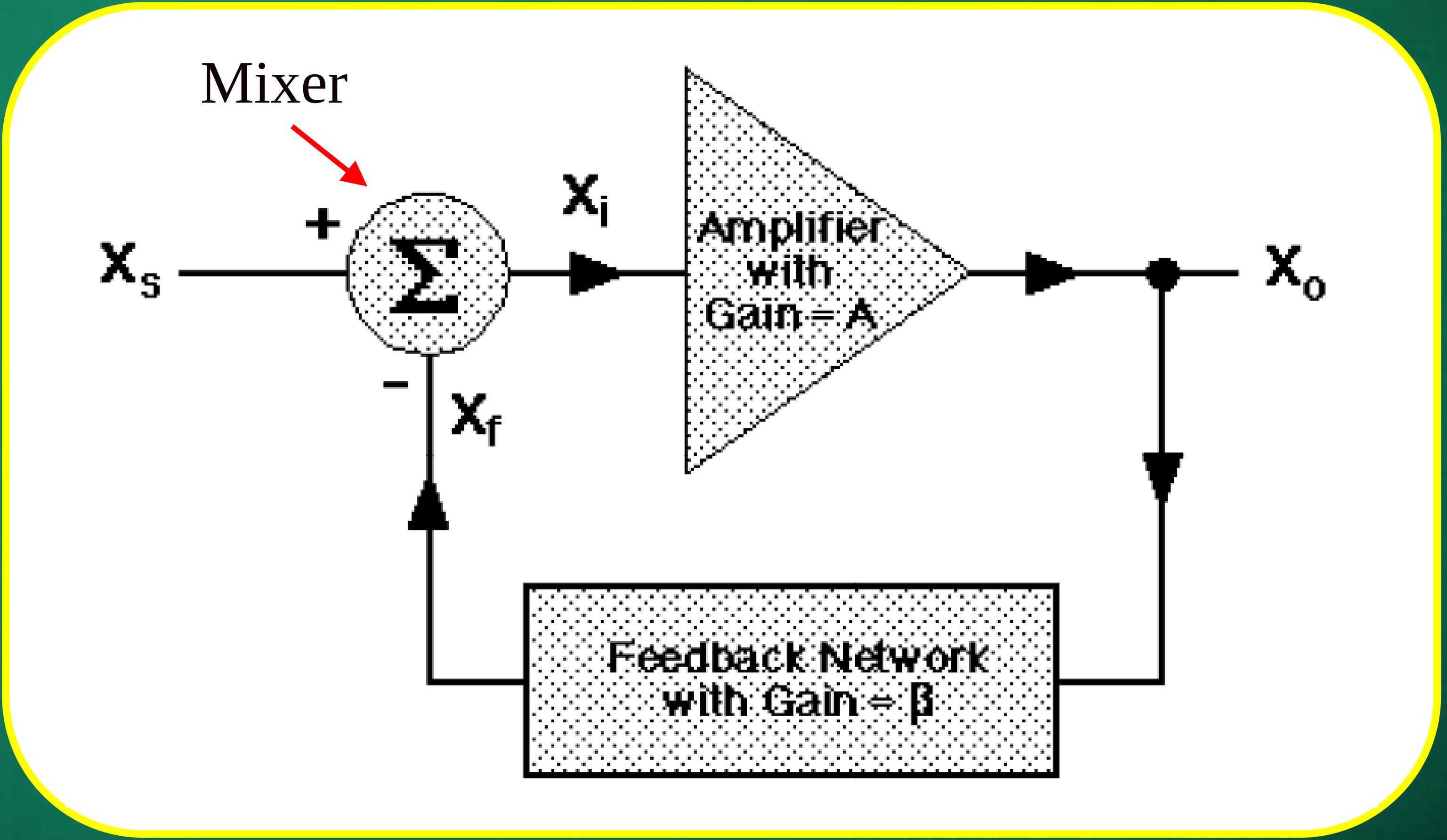


Ideal Amplifiers

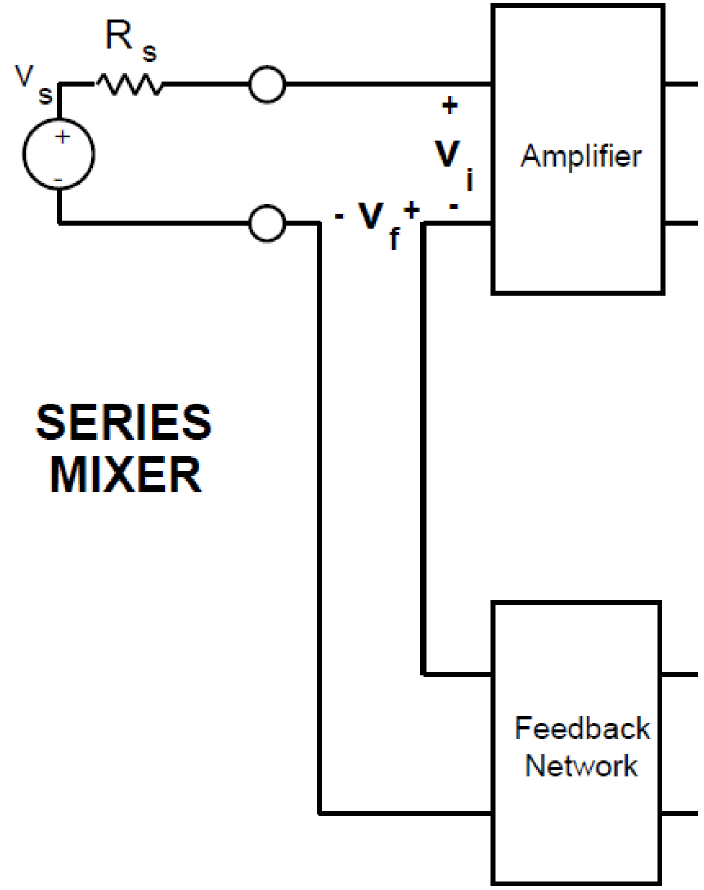
Type of Amplifier	Gain Expression	Ideal Input Impedance	Ideal Output Impedance
Voltage	$A_v = V_o/V_s$ Voltage Gain (dimensionless)	$Z_i = \infty$	$Z_o = 0$
Transconductance	$G_m = I_o/V_s$ Transconductance (Siemens)	$Z_i = \infty$	$Z_o = \infty$
Transresistance	$R_m = V_o/I_s$ Transresistance (Ohms)	$Z_i = 0$	$Z_o = 0$
Current	$A_i = I_o/I_s$ Current Gain (dimensionless)	$Z_i = 0$	$Z_o = \infty$

Types of Mixers

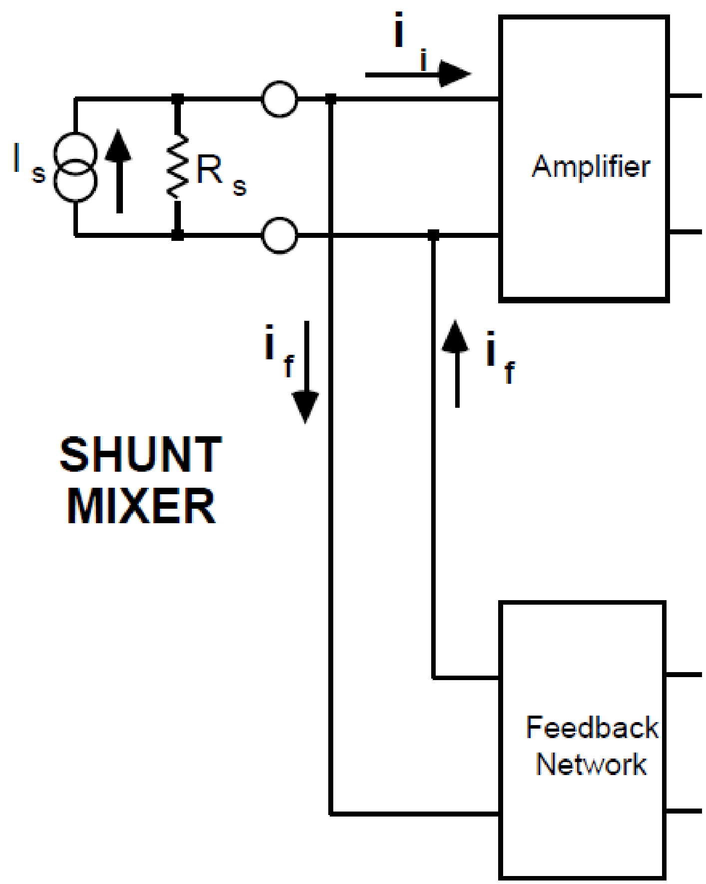
Basic Block Diagram



Series Mixer

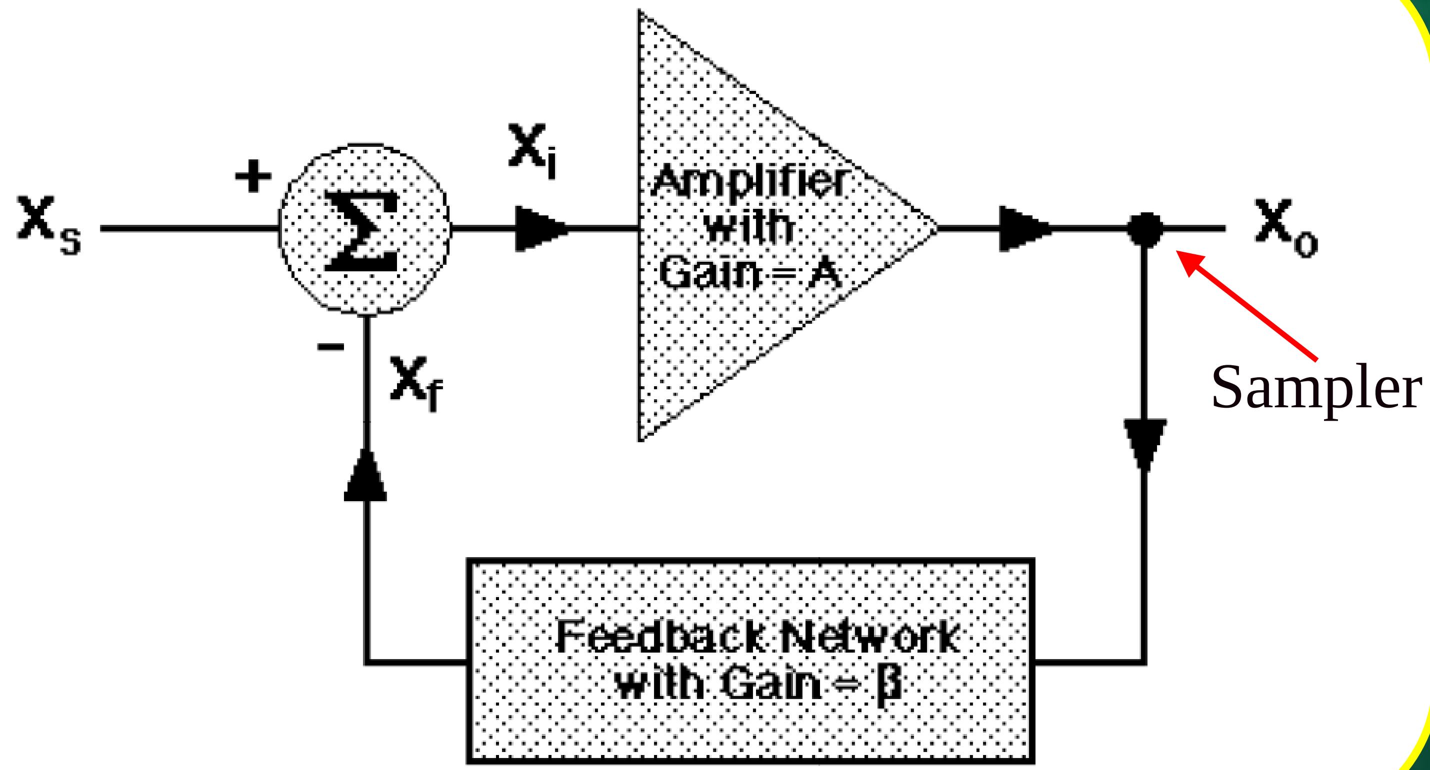


Shunt Mixer

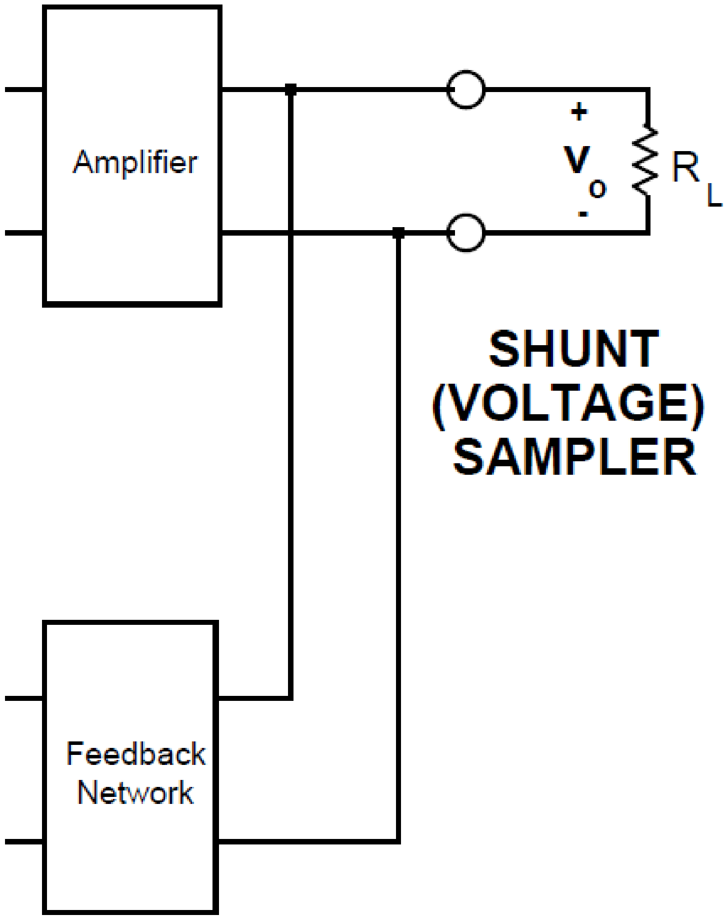


Types of Samplers

Basic Block Diagram



Shunt Sampler



Series Sampler