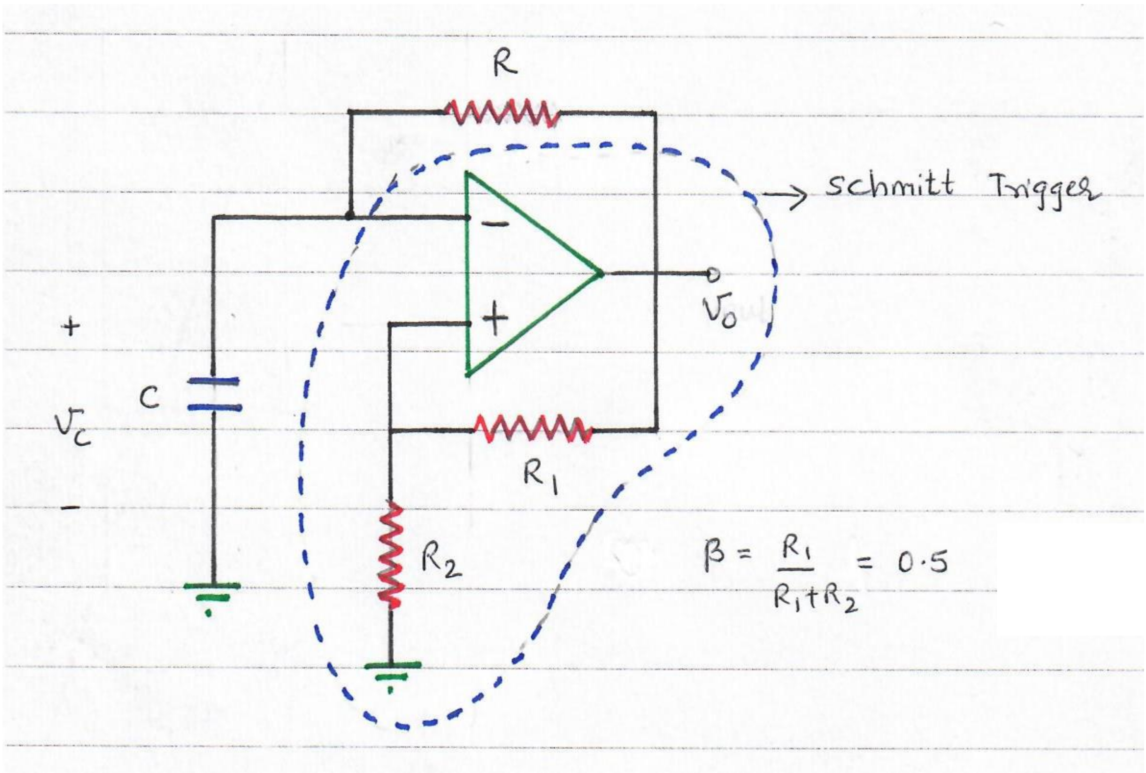
Basic Electronic Circuits (IEC-103)

Lecture-09

Square Wave Generator

Square Wave Generation



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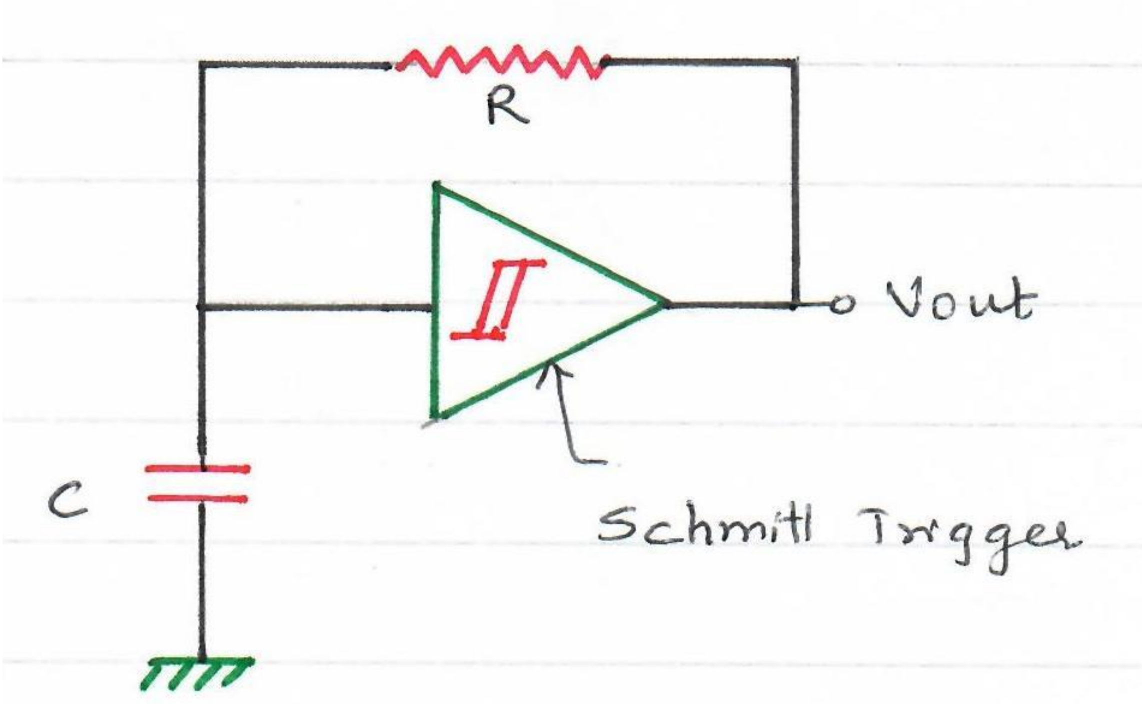
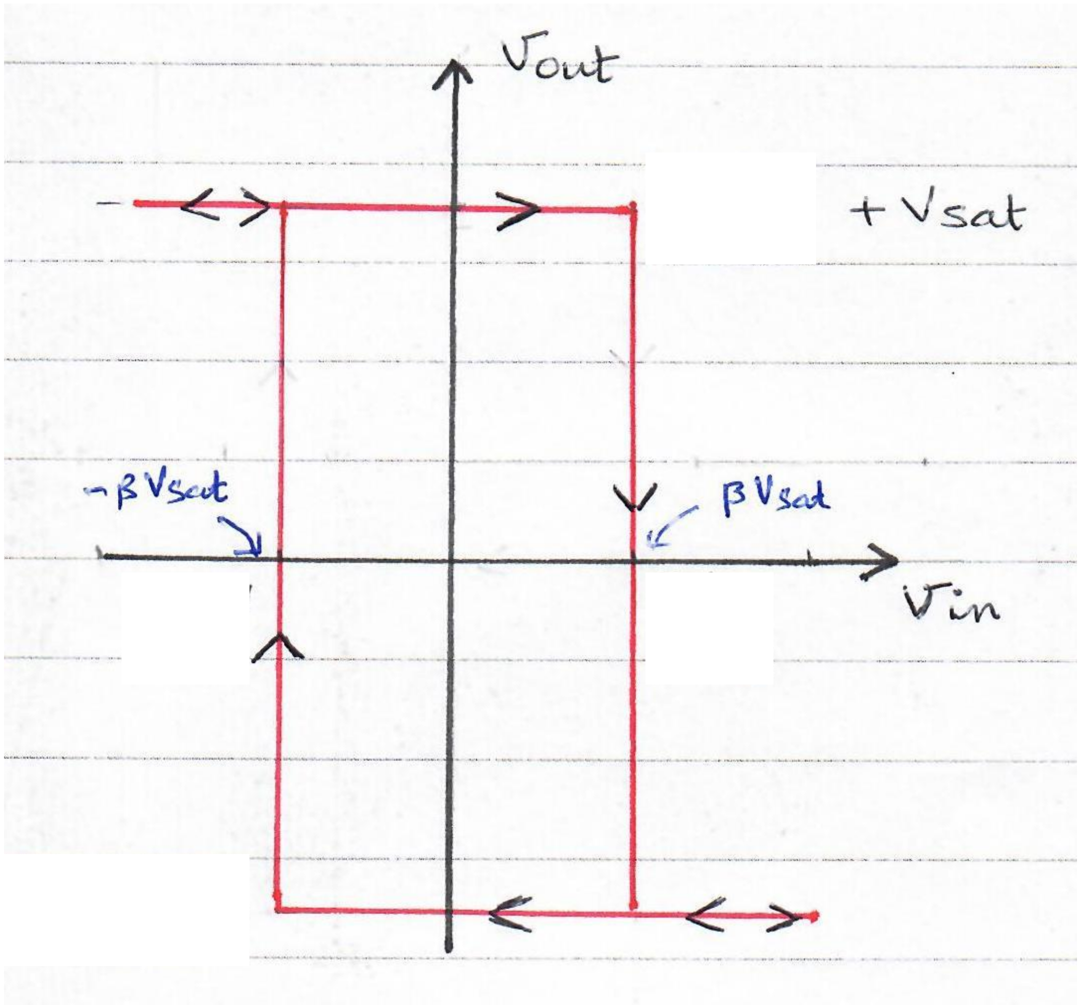
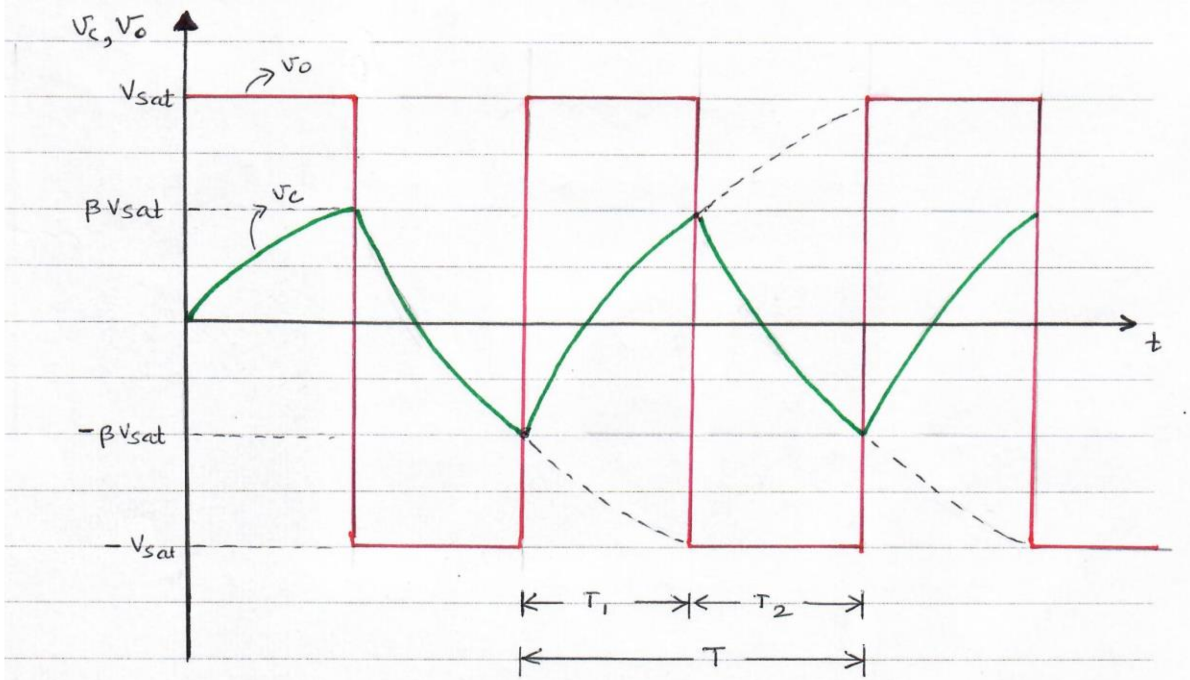


Transfer Characteristics



Output and Capacitor Voltage



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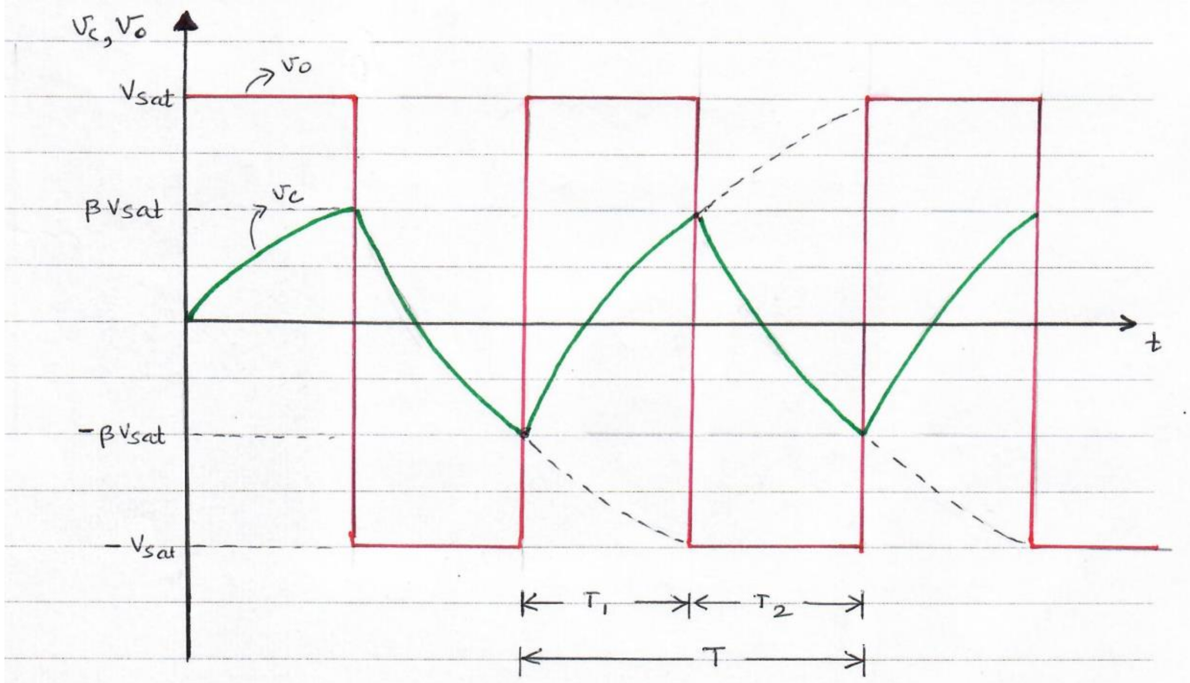
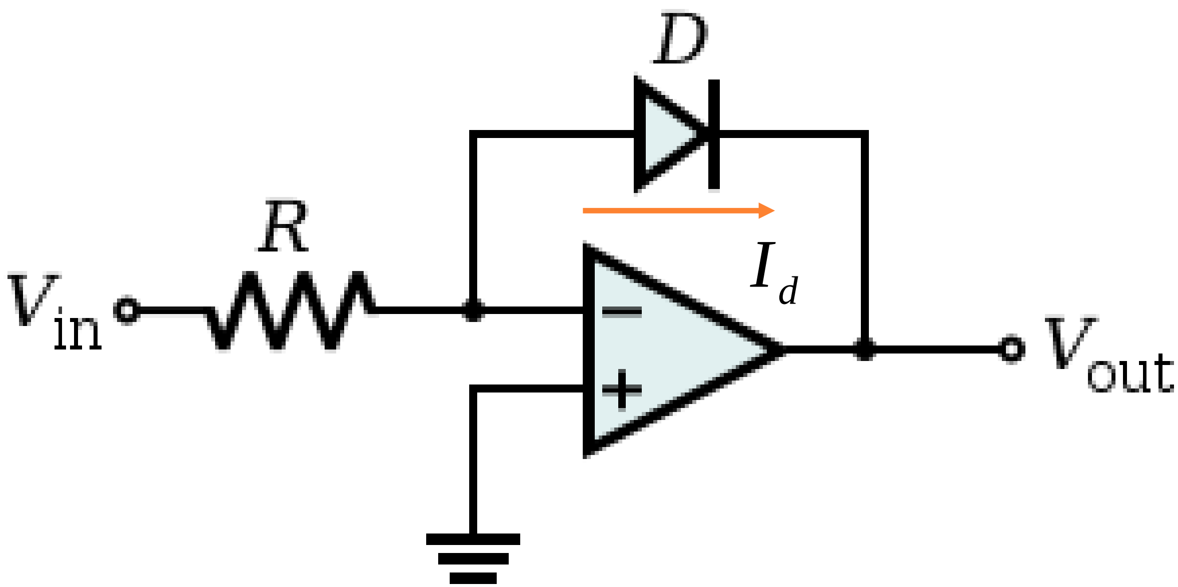


$$\Rightarrow T = 2RC\ln\left(\frac{1+0.5}{1-0.5}\right) = 2RC\ln(3) = 2.197RC$$

Log and Antilog Amplifier

Logarithmic Amplifier



Diode Equation

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i_D = the net current flowing through the diode;
I_0 = "dark saturation current", the diode leakage current in the absence of light;
v_D = applied voltage across the terminals of the diode;
q = absolute value of electron charge (1.6×10^{-19} C);
k = Boltzmann's constant (1.38×10^{-23} J/K);
T = absolute temperature in Kelvin (K); and
n = empirical constant, 1 for Ge and 2 for Si diode.

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At 300 K, kT/q = 26 mV, the thermal voltage.

Diode Equation

$$i_D = I_0\left(e^{\left(\frac{v_D}{0.026}\right)} - 1\right)$$

where v_D is the voltage applied across diode in volts.

If diode is forward biased

$$i_D \cong I_0 e^{\left(\frac{v_D}{0.026}\right)}$$

Analysis

Applying KCL at inverting input

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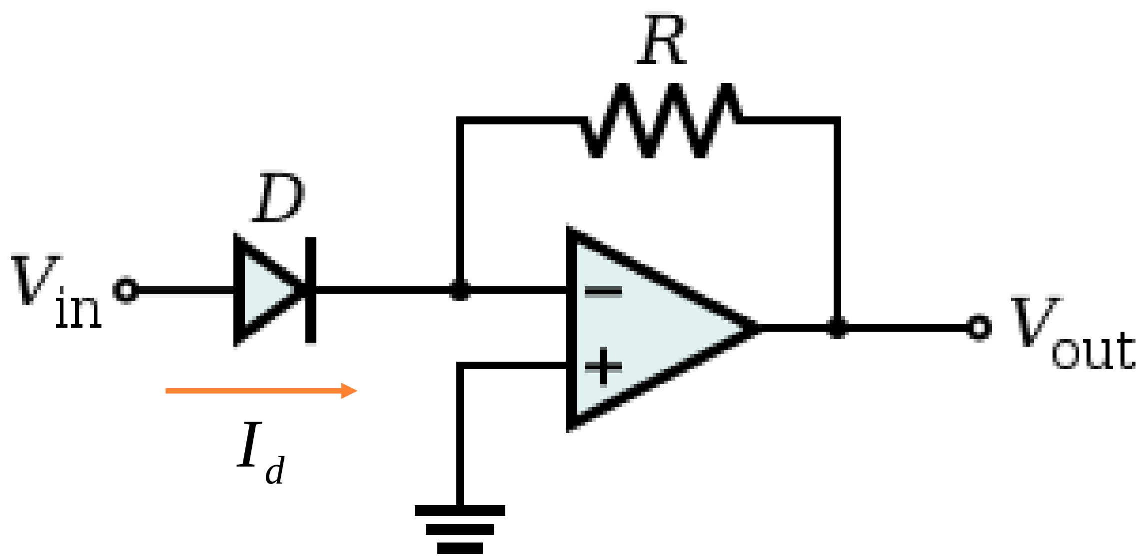
where $k_1 = -v_T$ and $k_2 = I_0 R$

Antilog Amplifier



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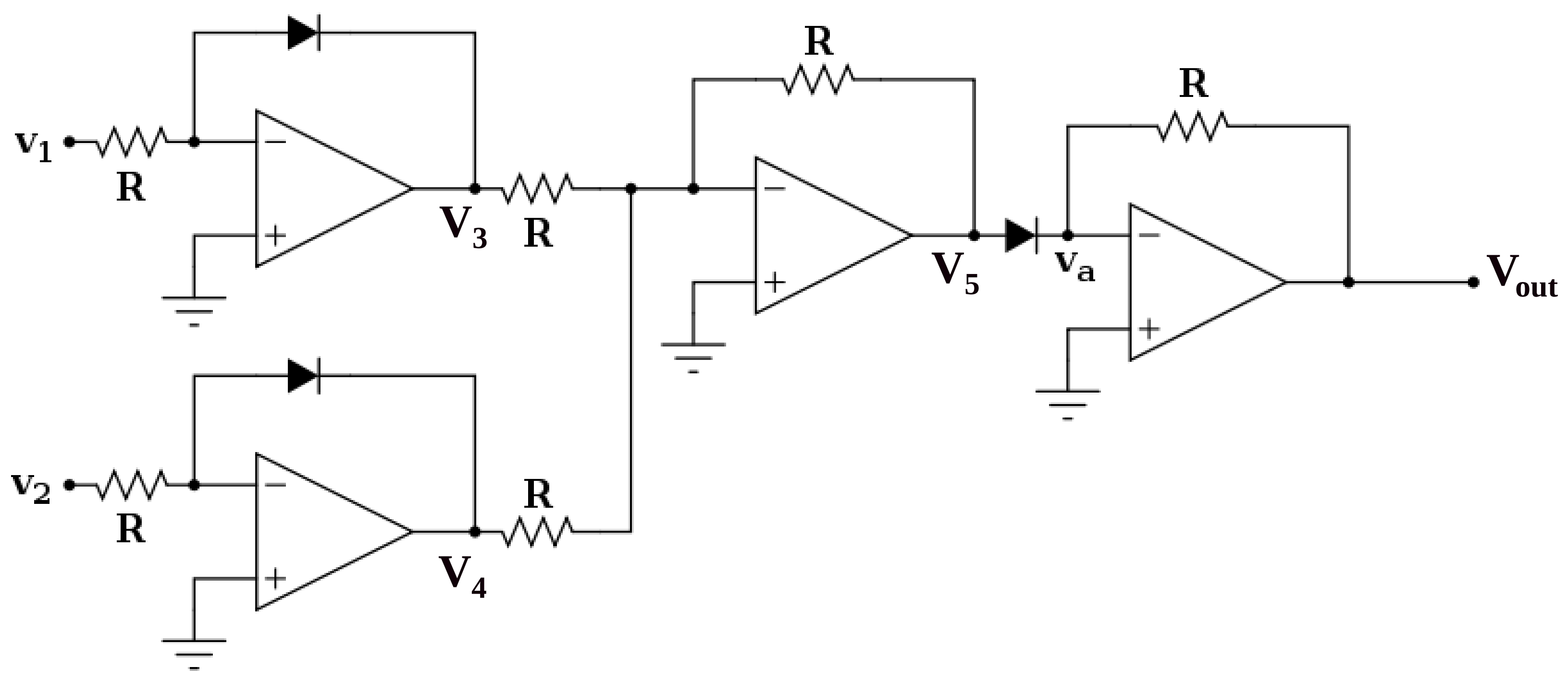
$$V_{out} = -RI_0 e^{(v_{in}/v_T)} = k_3 e^{v_{in}}$$

This amplifier is called exponential amplifier.

Other Nonlinear Amplifiers

Build a multiplying and squaring amplifier using op-amp.

Analog Multiplier



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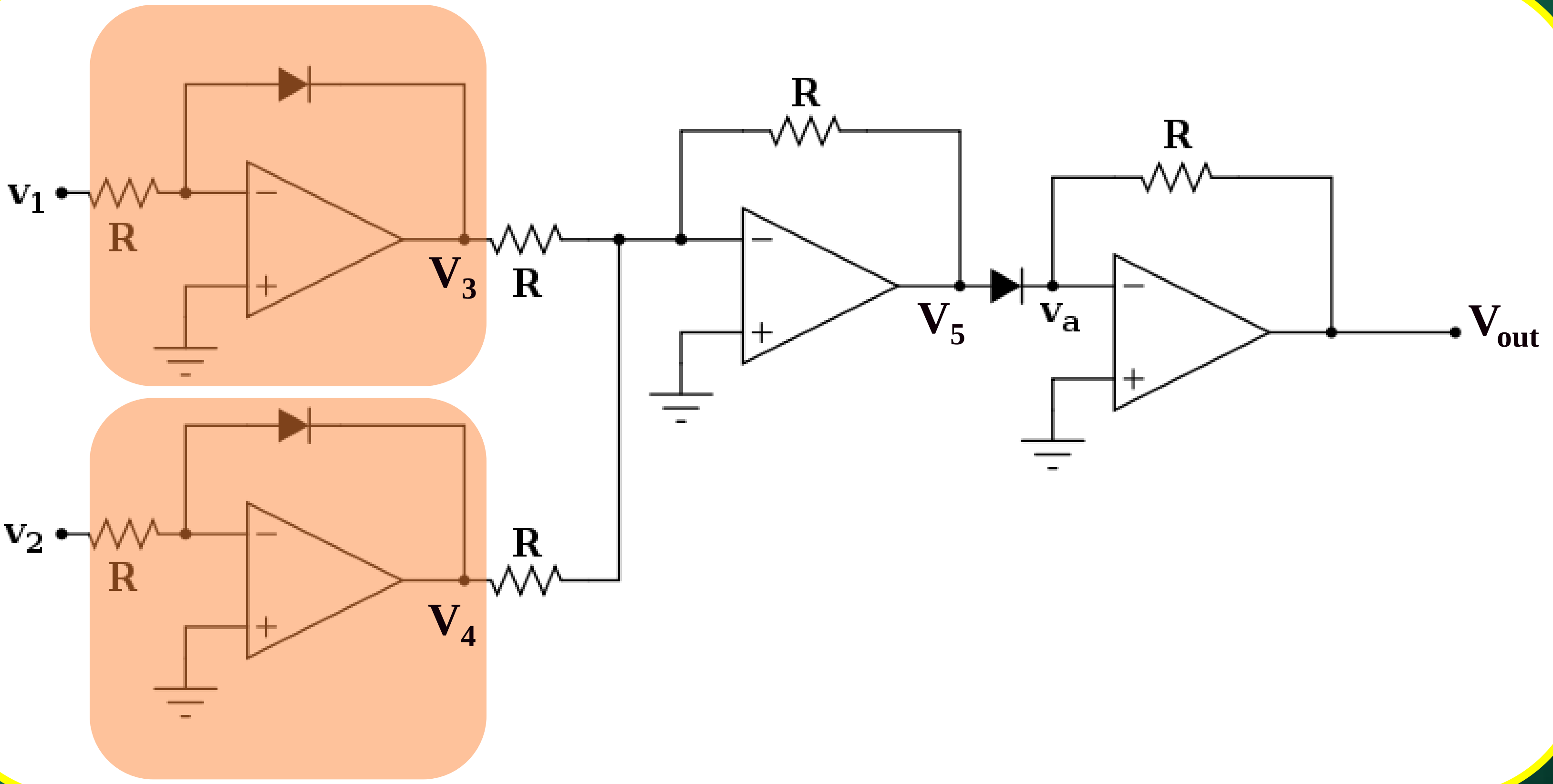

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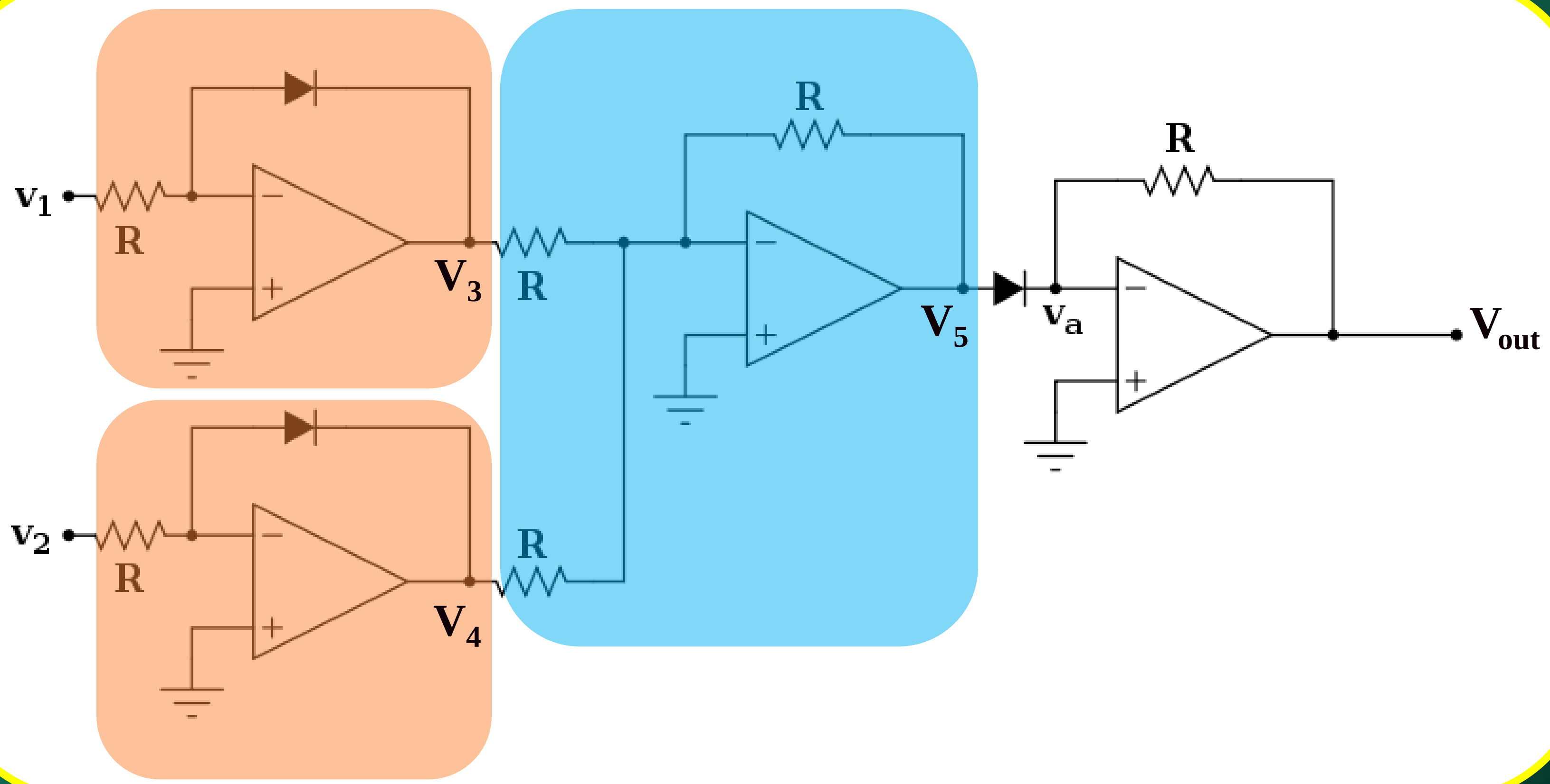

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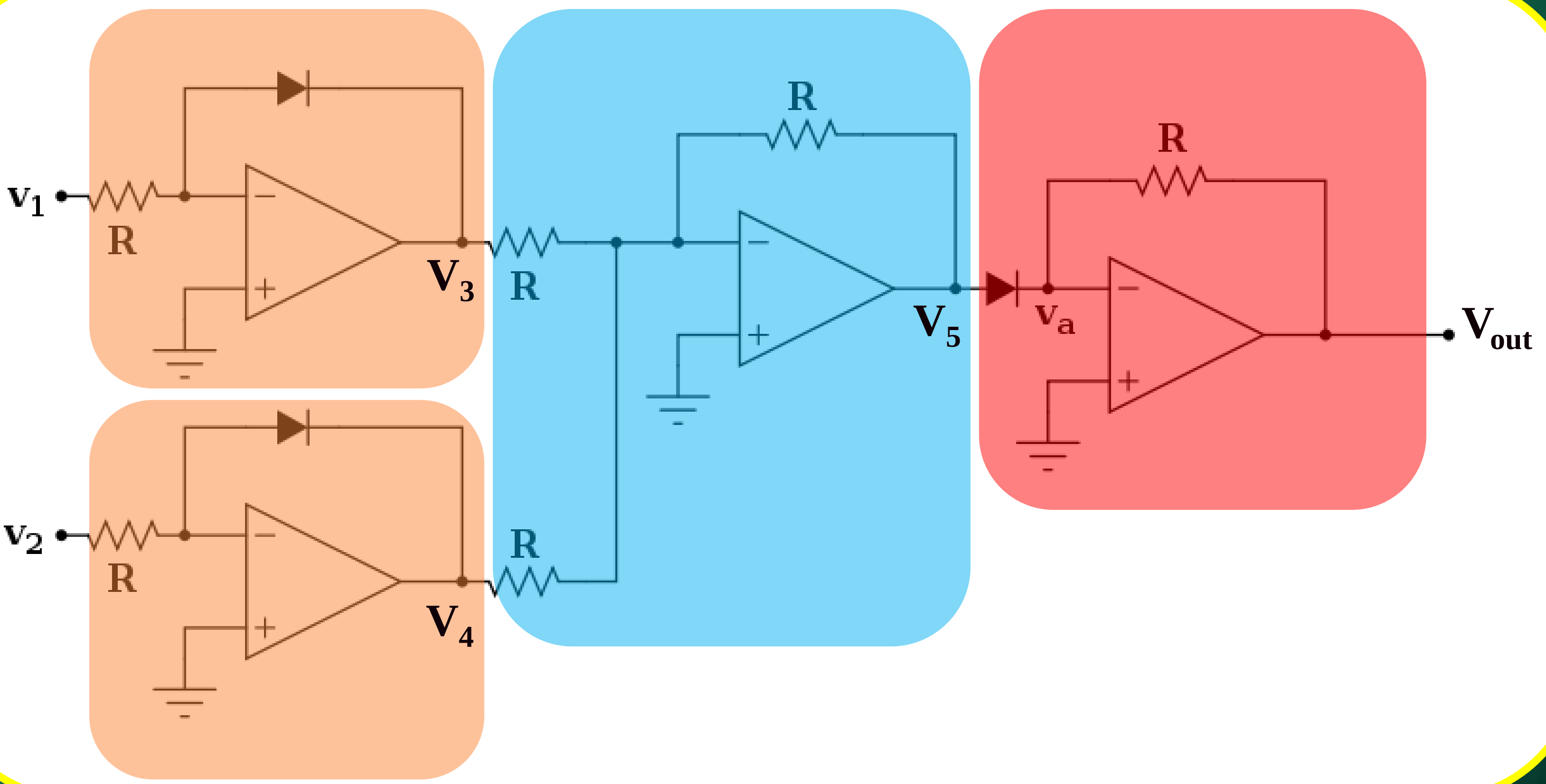
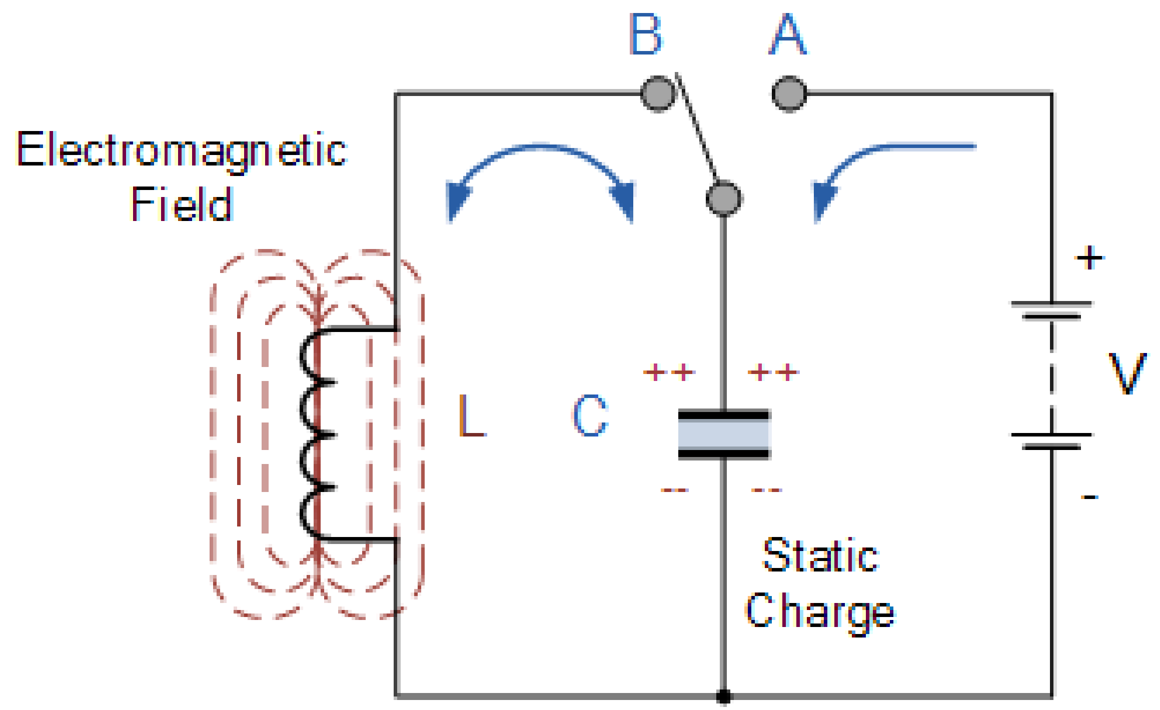


Analog Multiplier

$$V_{out} \propto V_1 V_2$$

Sinusoidal Oscillators

LC Tank Circuit



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$$f_r = \frac{1}{2\pi\sqrt{LC}}$$

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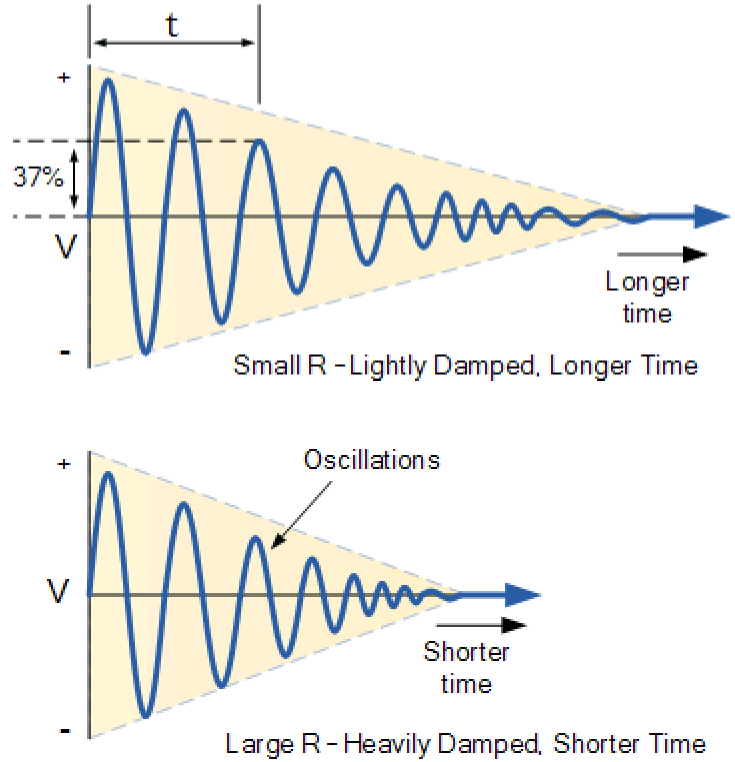

Oscillators

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- It produces a periodic waveform on its output with only the DC supply voltage as an input.
- The output voltage can be either sinusoidal or non-sinusoidal, depending on the type of oscillator.

Oscillators

- Different types of oscillators can produce various types of outputs including sine, square, saw tooth, and triangular waveforms.

Oscillators

For a circuit to operate as an oscillator following three basic factors must be provided in the circuit

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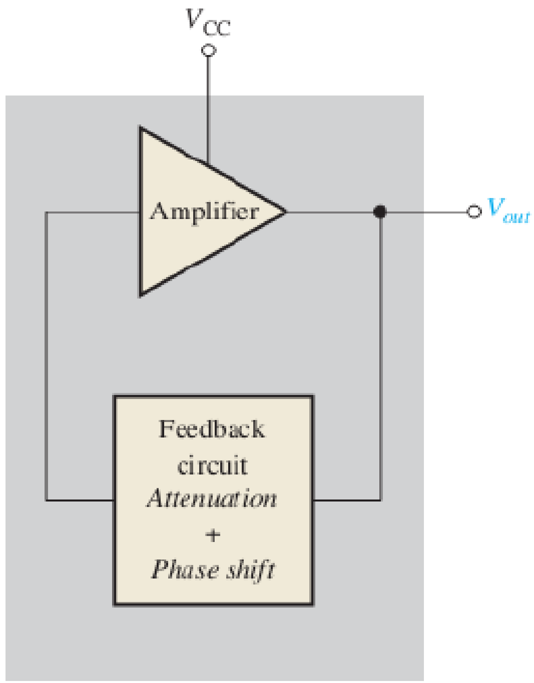
For a circuit to operate as an oscillator following three basic factors must be provided in the circuit

- Amplification
- Positive feedback
- Frequency determining network

Oscillators

Oscillators



Oscillator

Types of Oscillators

1. Feedback Oscillator
2. Relaxation Oscillators

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- Feedback Oscillators
  - A fraction of output is feedback to the input with no net phase shift.
  - The loop gain must be maintained at 1 to maintain oscillations
  - Amplifier can be made of either discrete transistor or an op-amp.

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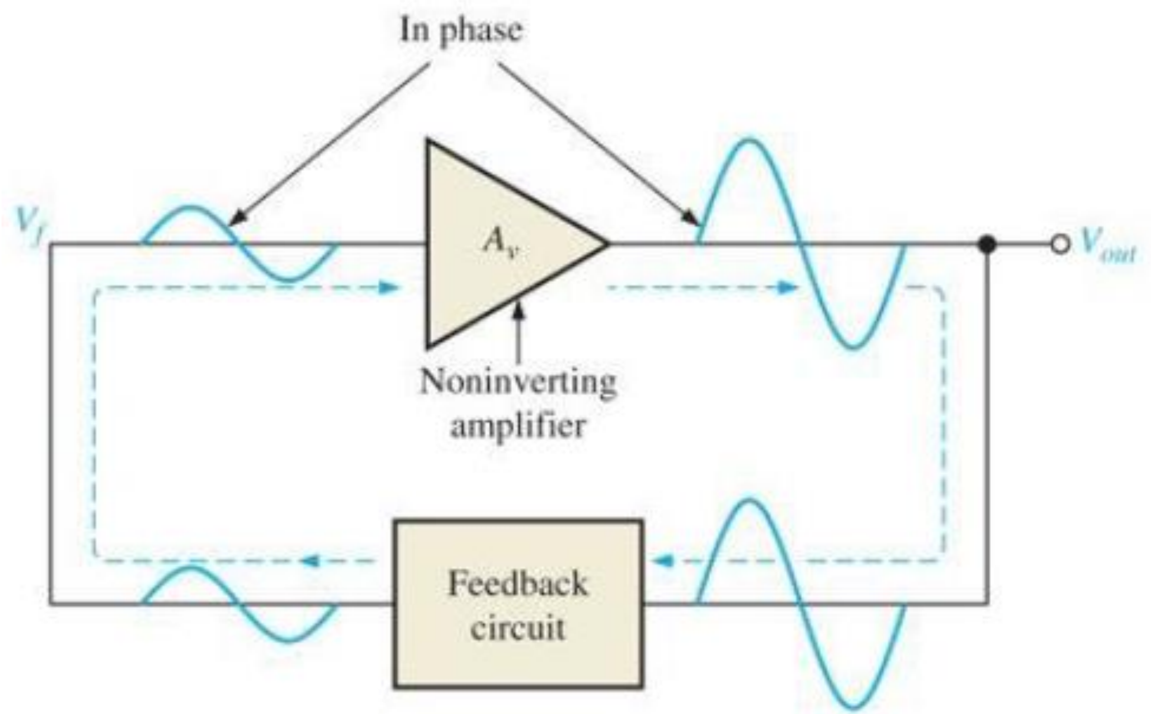
- **Relaxation Oscillators**
  - An RC timing circuit is used to generate oscillations.
  - The circuit operates in nonlinear region.
  - Example: Schmitt trigger based square wave oscillator.

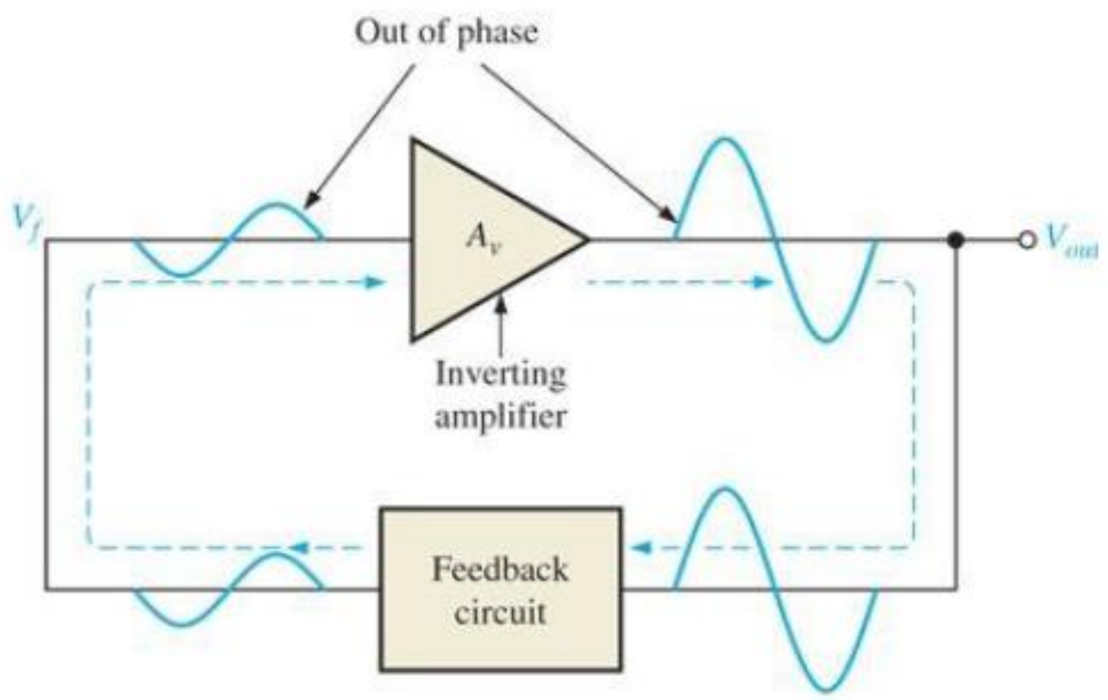
Positive Feedback

A portion of the output is fed back to the input with no net phase shift, resulting in strengthening of the output signal.

Positive Feedback



Positive Feedback



Conditions for Oscillations

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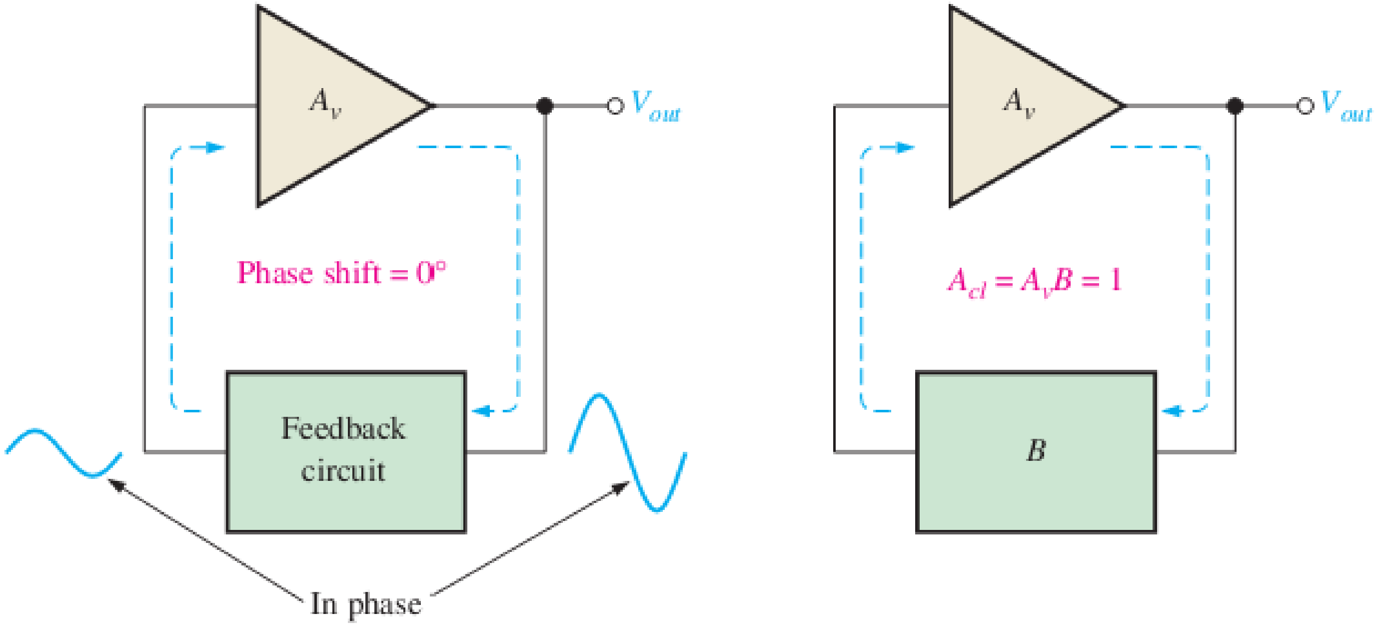
2. The voltage gain $A\beta$ around the closed feedback loop (loop gain) must be equal to 1.

Conditions for Oscillations



(a) The phase shift around the loop is 0°.

(b) The closed loop gain is 1.

RC and LC Oscillators

RC **Oscillators: The frequency determining network contains only resistive and capacitive elements.**

- Wein bridge oscillator
- Phase-shift oscillator
- Twin-T oscillator

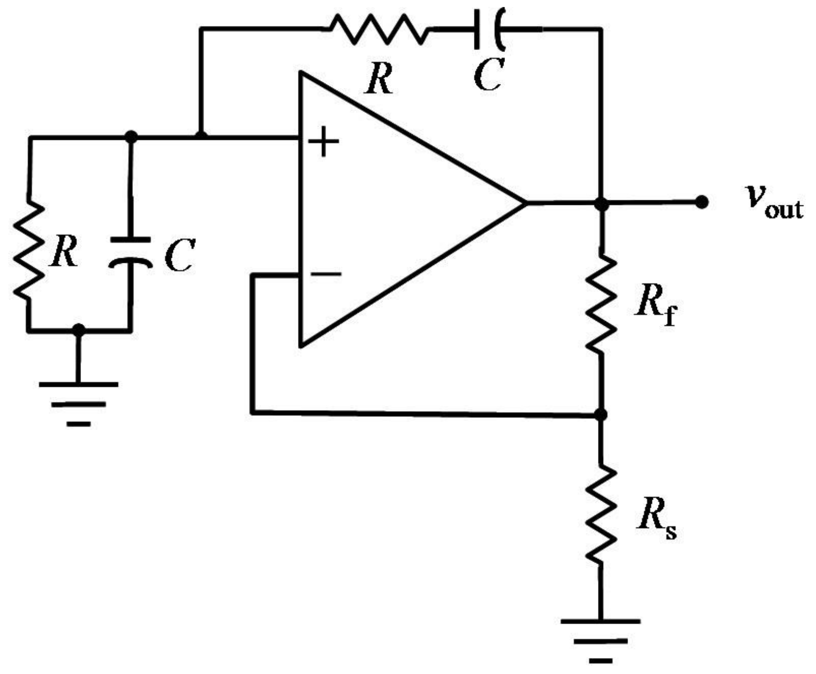
RC and LC Oscillators

LC **Oscillators: The frequency determining network contains inductive and capacitive elements.**

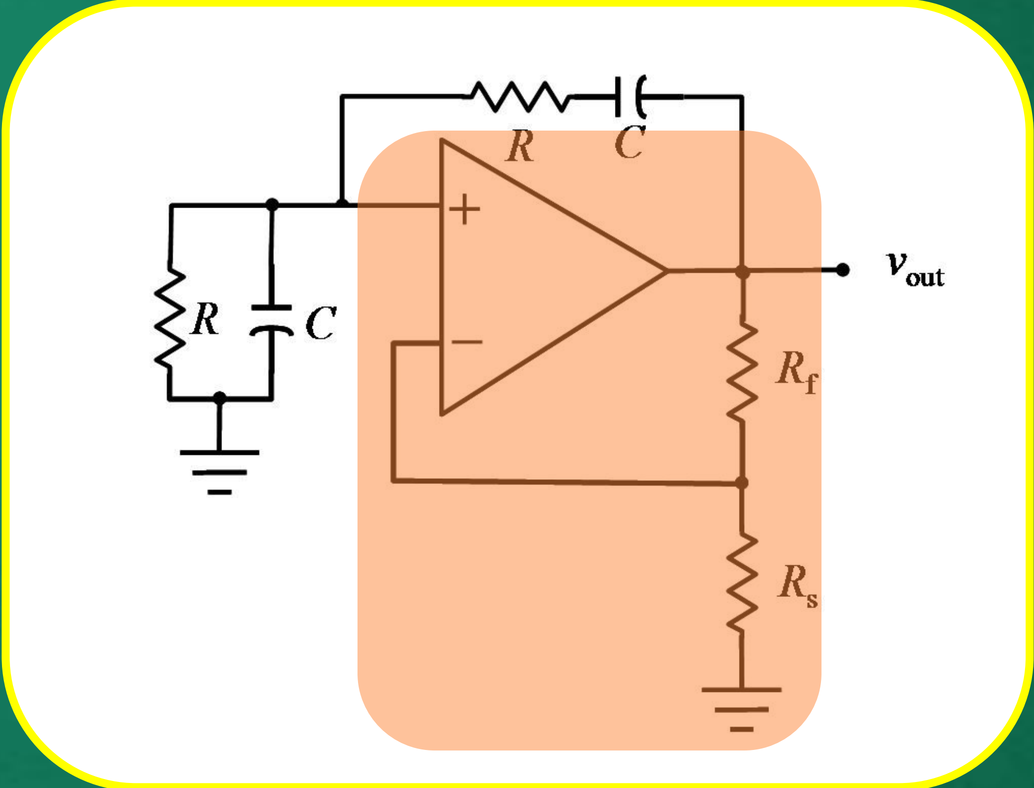
- **Hartly**
- **Colpitts**
- **Capp**
- **Pierce**

RC Oscillators

Wein Bridge Oscillator



Wein Bridge Oscillator



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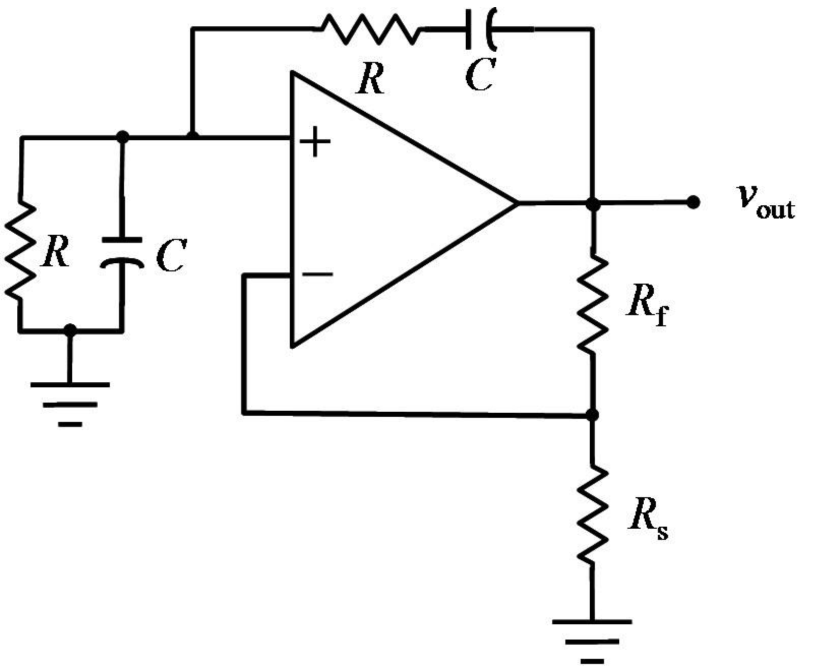
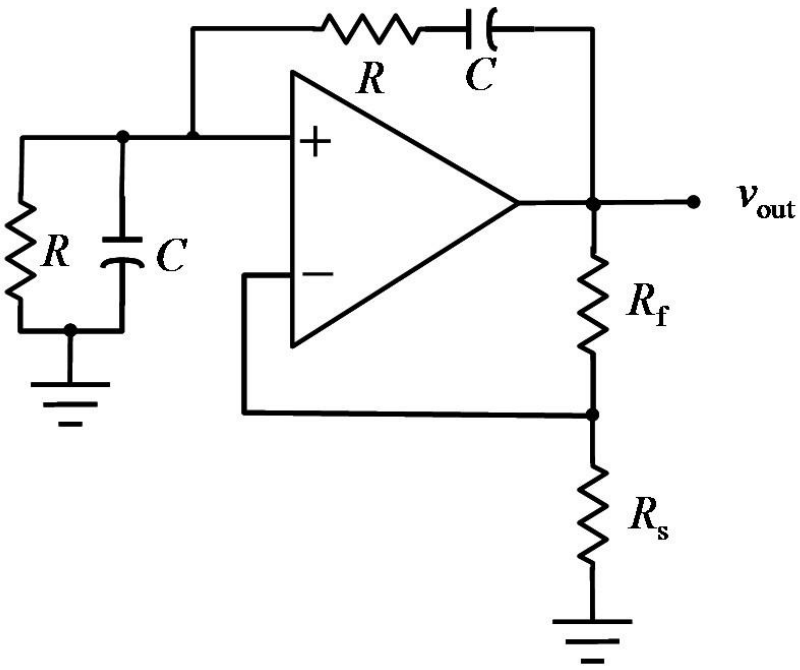


$$R_F = 2R_s$$

Wein Bridge Oscillator



$$R_F = 2R_s$$

$$\omega = \frac{1}{RC}$$

RC Phase Shift Oscillator