Indian Institute of Information Technology, Sri City, Chittoor
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Op-Amp as Integrator and Differentiator

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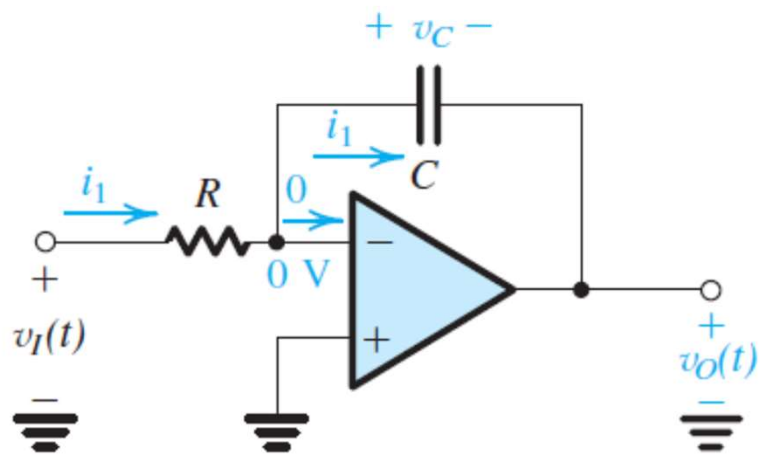
The Inverting Integrator

$$v_C(t) = V_C + \frac{1}{C}\int_0^t i_1(t)dt$$

$$v_O(t) = -\frac{1}{CR}\int_0^t v_I(t)dt - V_C$$



$$\frac{V_o(j\omega)}{V_i(j\omega)} = -\frac{1}{j\omega CR}$$

$$\left|\frac{V_o}{V_i}\right| = \frac{1}{\omega CR}$$

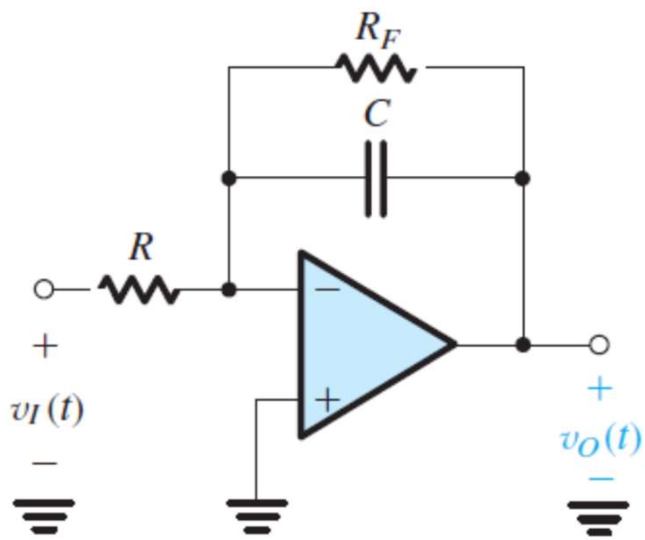
Example:

- Use an ideal op-amp to design an inverting integrator with an input resistance of 10 kΩ and an integration time constant of 10^{-3} s. What is the gain magnitude and phase angle of this circuit at 10 rad/s and at 1 rad/s? What is the frequency at which the gain magnitude is unity?

Circuit with finite gain at DC

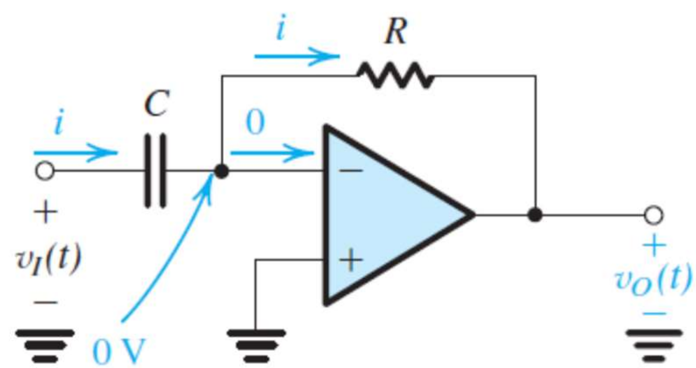
$$V_o = -\frac{1}{j\omega RC + R/R_F} V_i$$

$$\left|\frac{V_o}{V_i}\right| = \frac{R_F/R}{\sqrt{1+(\omega R_F C)^2}}$$



Differentiator Circuit

$$V_o = -j\omega RC_F V_i$$



Example:

- Design a differentiator to have a time constant of 10^{-2} s and an input capacitance of 0.01 μF. What is the gain magnitude and phase of this circuit at 10 rad/s, and at 10^3 rad/s? In order to limit the high-frequency gain of the differentiator circuit to 100, a resistor is added in series with the capacitor. Find the required resistor value.