IIT ROORKEE

NPTEL ONLINE CERTIFICATION COURSE

Microelectronics: Devices to Circuits

Op-amp as an Integrator and Differentiator

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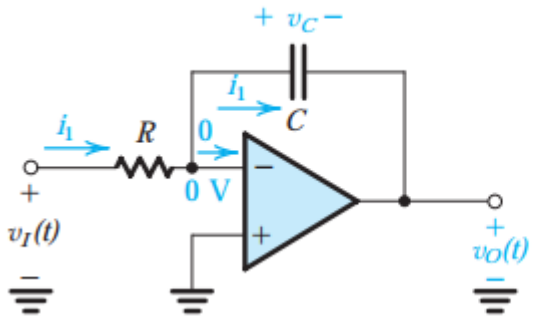
Outline

- Inverting Integrator
- Op-Amp Differentiator
- Recapitulation

Inverting Integrator

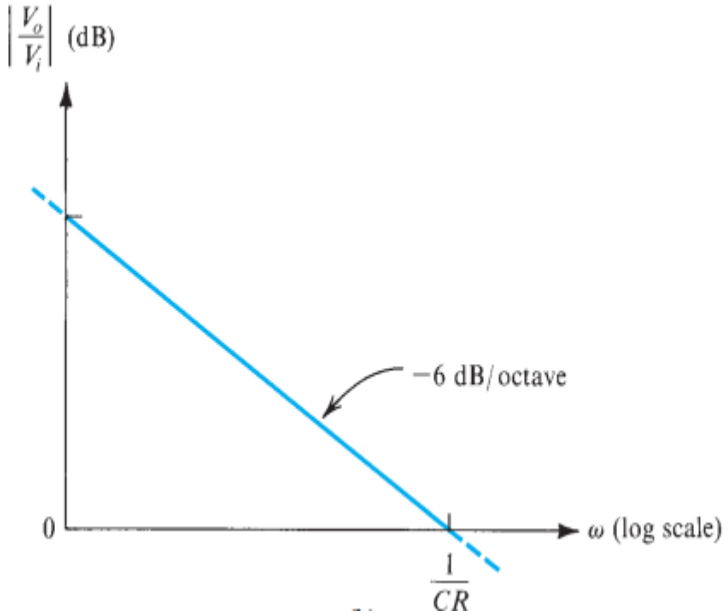
$$v_C(t) = V_C + \frac{1}{C}\int_0^t i_1(t)dt \qquad v_o(t) = -v_C(t)$$

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



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

$$\frac{V_o}{V_i} = -\frac{1}{sCR}$$

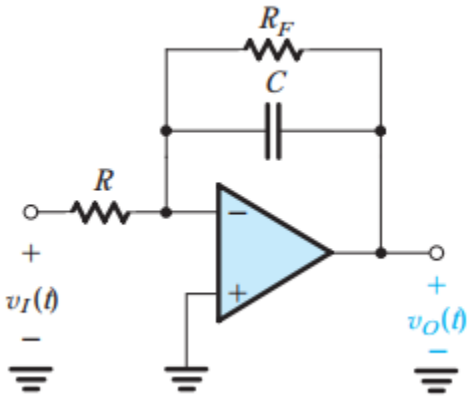


$$\frac{V_0(S)}{V_i(S)} = -\frac{1}{SCR}$$

Source: Microelectronics Circuits, Sedra and Smith, Fifth edition

$$\frac{V_0(jw)}{V_i(jw)} = -\frac{1}{jwCR} \qquad S=jw \qquad \left|\frac{V_0}{V_i}\right| = \frac{1}{wRC}$$

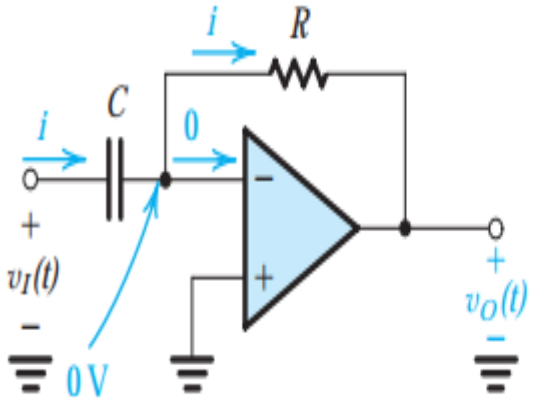
$$w_{\text{int}} = \frac{1}{RC} \qquad \phi = 90^0$$



$$\frac{V_0(S)}{V_i(S)} = -\frac{R_F/R}{1+sCR_F}$$

Source: Microelectronics Circuits, Sedra and Smith, Fifth edition

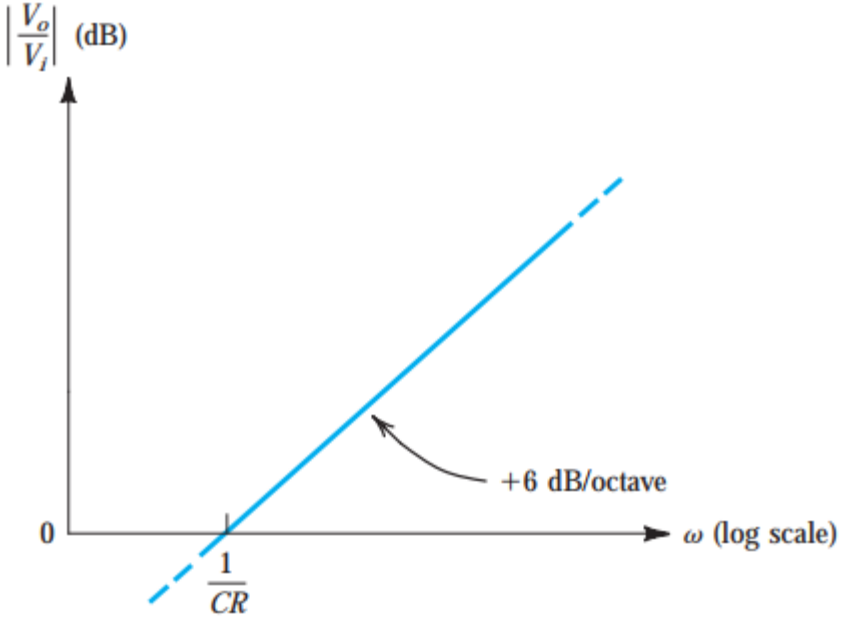
Op-Amp Differentiator



$$i(t) = C\frac{dv_I(t)}{dt}$$

$$v_O(t) = -CR\frac{dv_I(t)}{dt}$$

$$\frac{V_o}{V_i} = -sCR$$



Source: Microelectronics Circuits, Sedra and Smith, Fifth edition

$$v_0(t) = -CR\frac{dv_I(t)}{dt} \qquad \phi = 90^0$$

$$\frac{V_0(S)}{V_i(S)} = -sCR$$

$$\frac{V_0(jw)}{V_i(jw)} = -jwCR \qquad \left|\frac{V_0}{V_i}\right| = wCR$$

Source: Microelectronics Circuits, Sedra and Smith, Fifth edition

Recapitulation

- The integrator behaves as a low-pass filter with a corner frequency of zero.
- The frequency response of the differentiator can be thought of as that of an STC high pass filter with a corner frequency at infinity.

Source: Microelectronics Circuits, Sedra and Smith, Fifth edition

Thank You