Practical OP-AMP Circuits
Op-Amp Applications

» Controlled Sources

(c) Voltage Controlled Voltage Source (VCVS)
(b) Voltage Controlled Current Source (VCCS)
(c) Current Controlled Voltage Source (CCVS)
(d) Current Controlled Current Source (CCCS)
(a) Voltage Controlled Voltage Source (VCVS)

\[ V_o = kV_i \]

Ideal voltage controlled voltage source
\[ V_o = -\frac{R_f}{R_1} V_i = kV_i \]
\[ V_o = \left(1 + \frac{R_f}{R_1}\right)V_i = kV_i \]
(b) Voltage Controlled Current Source (VCCS)

\[ I_0 = kV_i \]

Ideal voltage controlled current source
(b) Voltage Controlled Current Source (VCCS)

\[ I_o = I_i = \frac{V_i}{R} = \frac{1}{R} V_i = kV_i \]
Voltage Controlled Current Source (VCCS)

This circuit is useful when the load $R_L$ is floating
(c) Current Controlled Voltage Source (CCVS)

\[ V_o = kI_i \]
$V_o = -I_i R_L$
Current Controlled Voltage Source (CCVS)

\[ V_o = -RI_S + R_I_S = 0 \]
(d) Current Controlled Current Source (CCCS)

\[ I_o = kI_i \]
\[ I_1 = I_o + I_2 \]

\[ I_o = I_1 - I_2 = I_1 - \left( \frac{-I_1 R_1}{R_2} \right) = I_1 \left( 1 + \frac{R_1}{R_2} \right) = kI_1 \]