EE539: Analog Integrated Circuit Design

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14/3/06

SWITCHED CAPACITOR.
Average current = $\frac{CV_T}{T_s}$

$$R_{eq} = \frac{T_s}{C}$$

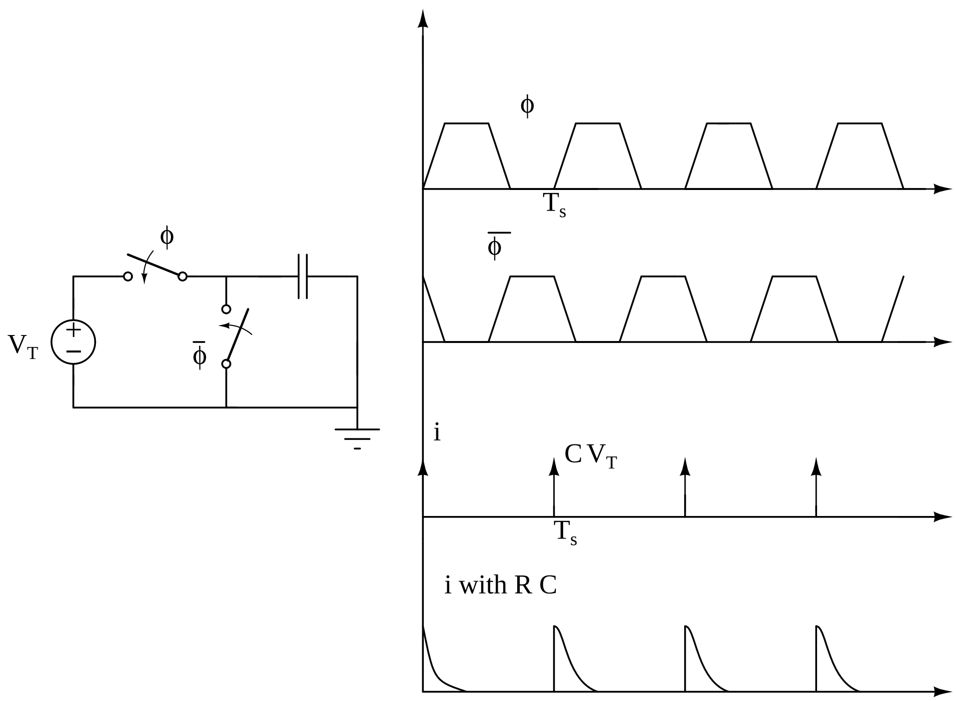

Figure 1: SWITCHED CAPACITOR

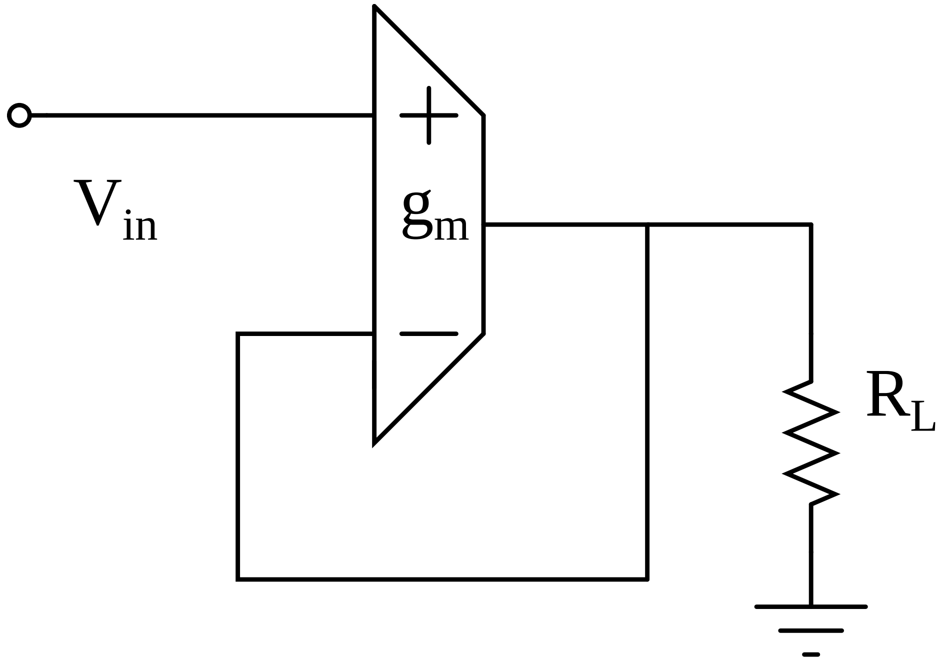

Figure 2: USING RESISTOR

$$
\begin{aligned}
G(s) &= g_m(R_o//R_L) && (1)\\
H(s) &= 1 && (2)\\
G_c(s) &= \frac{G(s)}{1+G(s)H(s)} && (3)\\
\frac{V_o(s)}{V_{in}(s)} &= \frac{1}{1+\frac{1}{g_m(R_o//R_L)}} && (4)\\
idealgain &= 1 && (5)\\
E(s) &= \frac{\frac{1}{g_m(R_o//R_L)}}{1+\frac{1}{g_m(R_o//R_L)}} && (6)
\end{aligned}
$$

$$E(s) \approx \frac{1}{g_m(R_o//R_L)} \qquad (7)$$

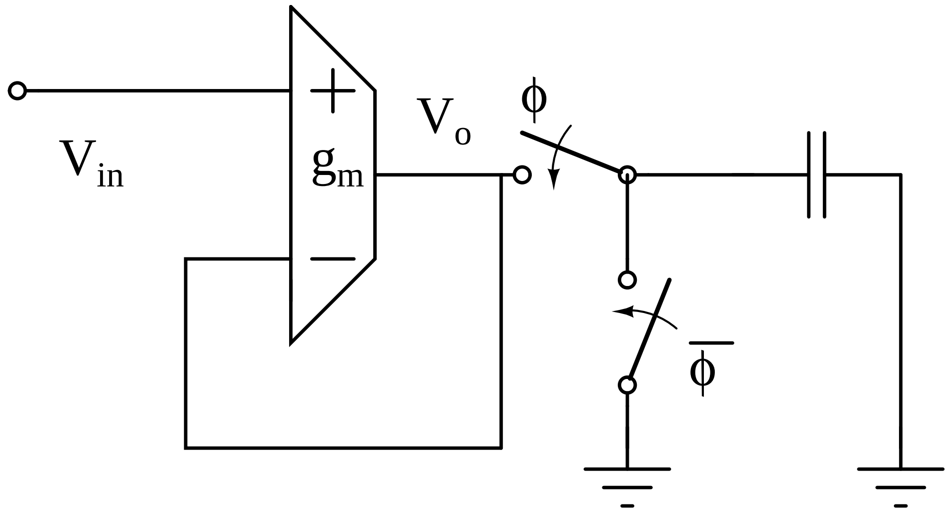

Figure 3: SWITCHED CAPACITOR

Replacing the switched capacitor with an equivalent resistor

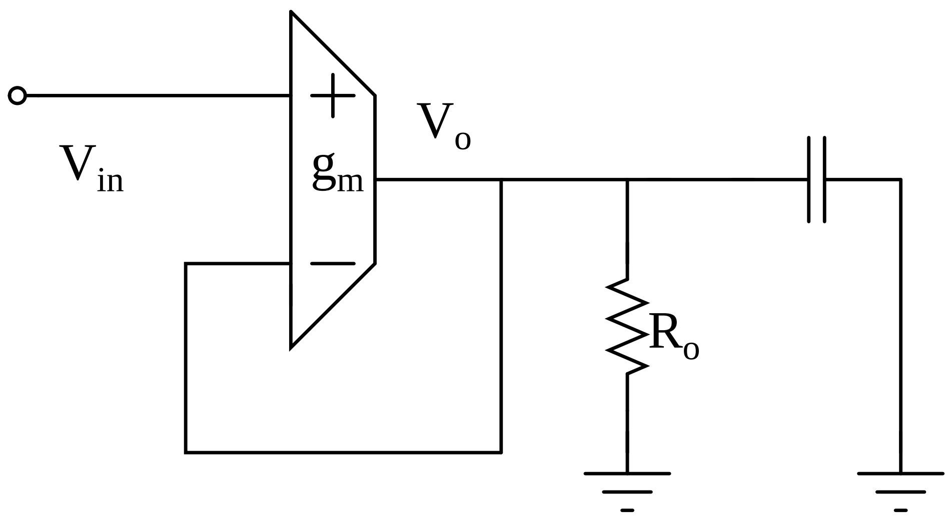

Figure 4: SWITCHED CAPACITOR

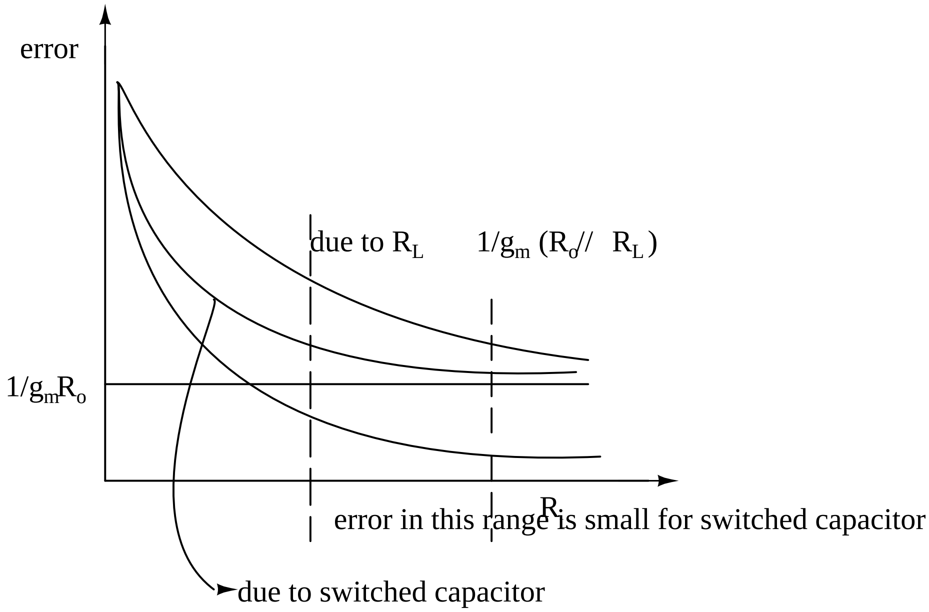

Figure 5: SWITCHED CAPACITOR

$$(V_{in} - V_o)g_m = V_o G_o + C V_o' \tag{8}$$

$$V_i \frac{g_m}{C} = V_o \frac{(g_m + G_o)}{C} + V_o' \tag{9}$$

$$finally V_o' = 0 \tag{10}$$

$$Therefore V_i \frac{g_m}{C} = V_o \frac{g_m + G_o}{C} \tag{11}$$

$$V_o = V_i\left(\frac{g_m}{g_m + G_o}\right) \tag{12}$$

$$Timeconstant \tau = \frac{C}{g_m + G_o} \tag{13}$$

$$V_o(t) = V_{final} + (V_{final} - V_{initial})(1 - \exp(\frac{-t}{\tau})) \tag{14}$$

$$V_o(t) = \frac{g_m}{g_m + G_o}(1 - \exp(-\frac{(g_m + G_o)t}{C}))V_i \tag{15}$$

$$\frac{V_o(\frac{T_s}{2})}{V_i} = \frac{g_m}{g_m + G_o}(1 - \exp\frac{(-(g_m + G_o)\frac{T_s}{2})}{C} \tag{16}$$

$$error = \frac{1}{g_m R_o} + \exp\frac{(-(g_m + G_o)\frac{T_s}{2}}{C}) \tag{17}$$

The first part is the error due to transconductance of the opamp and second part due to switched capacitor