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Midterm
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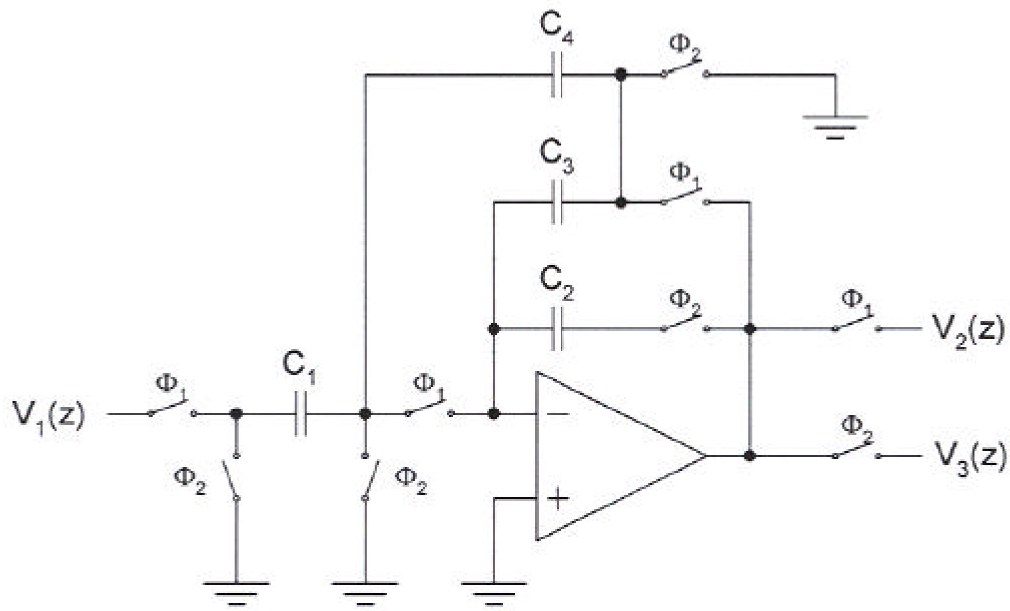
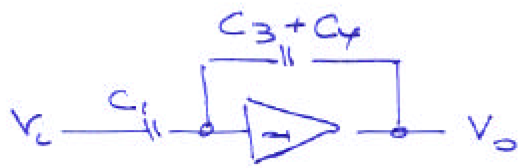
EECS 247
FALL 2000

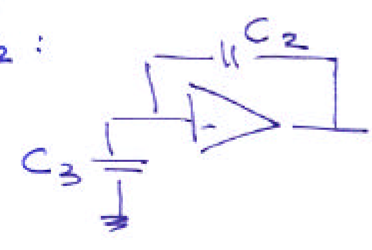
1. Find the following transfer functions (the amplifier is ideal):
   a) $H_1(z)=V_2(z) / V_1(z)$, during phase 1, and
   b) $H_2(z)=V_3(z) / V_1(z)$, for phase 1 input and phase 2 output.



Φ_1 :



Φ_2 :



(a) $H_1(z) = -\dfrac{C_1}{C_3+C_4}$ ||

(b) $Q_3 = -V_i \cdot \dfrac{C_1 \cdot C_3}{C_3+C_4} \cdot z^{-1}$

$Q_2 = C_2 \cdot V_o = C_2 \cdot V_o \cdot z^{-1} + Q_3$

$\Rightarrow H_2(z) = -\dfrac{C_1 \cdot C_3}{C_3+C_4} \cdot \dfrac{1}{C_2} \cdot \dfrac{z^{-1}}{1-z^{-1}}$ ||

Useful in large capacitor spread situations.

2. The transfer function H(s) is realized as a switched capacitor ladder filter with LDI integrators.

$$H(s) = \frac{0.0010005\ (s^2 + 1.235)\ (s^2 + 1.438)\ (s^2 + 2.408)\ (s^2 + 15.34)}{(s^2+0.4952s+0.1505)(s^2+0.28s+0.5605)(s^2+0.1106s+0.8742)(s^2+0.0272s+0.9987)}$$

a) Find the minimum clock frequency for the SC filter that is required to keep all zeros in the response.
b) What type of filter is H(s) realizing (low pass, band pass, etc)?

(a) $f_{RC,max} = \frac{f_s}{\pi}$

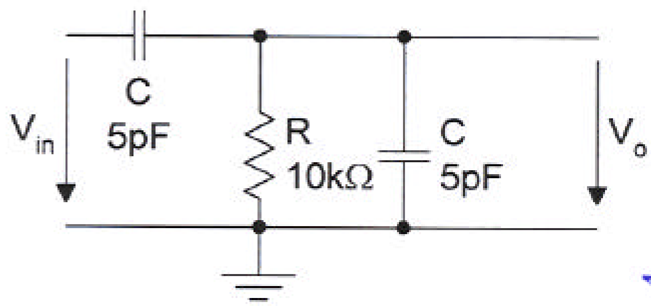
$\Rightarrow f_s \geq \pi \cdot f_{z,max} = \frac{\sqrt{15.34}}{2} = \underline{\underline{1.96\,Hz}}$

(b) $H(s)\big|_{s=0} = 0.8912$ or $-1dB$

$H(s)\big|_{s\to\infty} = 0.0010005$ or $-60dB$

$\Rightarrow \underline{\underline{LPF}}$

3. The output V_o of the filter shown below is processed by an ideal sampler operating at f_s=1MHz (e.g. an ideal A/D converter). V_{in} is a sinusoid with 1V amplitude and f_x=1.3MHz. Calculate the amplitude and frequency of the sampled output.



$\tau = RC = 50$ nsec.

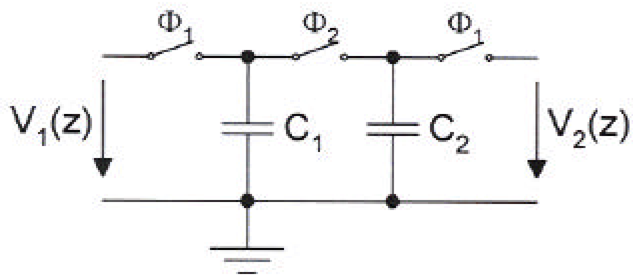
$$H(s) = \frac{s\tau}{1+2s\tau}$$

$$|H(\omega)|^2 = \frac{(\omega\tau)^2}{1+(2\omega\tau)^2}$$

$$|H(\omega = 2\pi f_x)| = 0.3163\,V = \text{Amplitude}$$

300 kHz = Frequency

4. Find the transfer function $H(z)=V_2(z)/V_1(z)$ of the following SC circuit (for Φ_1):



Φ_2:
$$Q_T = Q_1^{(1)} + Q_2^{(1)}$$
$$= C_1 \cdot V_1 \cdot z^{-1} + C_2 \cdot V_2 \cdot z^{-1}$$

$$V_2(z) = \frac{Q_T}{C_1 + C_2}$$

$$= \frac{C_1}{C_1+C_2} \cdot V_1 \cdot z^{-1} + \frac{C_2}{C_1+C_2} \cdot V_0 \cdot z^{-1}$$

$$V_2 \cdot \left(1 - \frac{C_2}{C_1+C_2} \cdot z^{-1}\right) = V_1 \cdot z^{-1} \cdot \frac{C_1}{C_1+C_2}$$

$$\Rightarrow H(z) = \frac{z^{-1} \cdot \frac{C_1}{C_1+C_2}}{1 - \frac{C_2}{C_1+C_2} \cdot z^{-1}}$$

(lowpass filter).