HW4 ECE580

Q1

(a). $(n-1)$th ϕ_1: $\left[V_2(n-1) - V_1(n-1)\right] C_1 + \left[0 - V_0(n-1)\right] C_2$

nth ϕ_2: $(C_1 + C_2)\left(0 - V_0(n)\right)$

$$z^{-1}\left(V_2(z) - V_1(z)\right) C_1 - z^{-1} V_0(z)\, C_2 = -V_0(z)\,(C_1 + C_2)$$

$$\Rightarrow \quad V_0(z) = \frac{z^{-1} C_1}{C_1 + C_2 - z^{-1} C_2}\left(V_1(z) - V_2(z)\right)$$

(b) $z_p = \frac{C_2}{C_1 + C_2} < 1 \iff$ stable $\iff$ circuit always stable.

(c). $(n-1)$th ϕ_1: $\left[V_2(n-1) - V_1(n-1)\right] C_1 + \left[-\frac{V_0(n-1)}{A} - V_0(n-1)\right] C_2 + \left(-\frac{V_0(n-1)}{A}\right) C_p$

nth ϕ_2: $\left[-\frac{V_0(n)}{A} - V_0(n)\right](C_1 + C_2) + \left[-\frac{V_0(n)}{A}\right] C_p$

$$\Rightarrow V_0(z) = \frac{z^{-1} C_1 \left[V_1(z) - V_2(z)\right]}{\left(1 + \frac{1}{A}\right)\left[C_1 + C_2 - z^{-1} C_2\right] + \left(1 - z^{-1}\right)\frac{C_p}{A}}$$

Q2: ϕ_1: $-V_{in} \cdot 2C_1$

ϕ_2: $-V_{ref} \cdot C_1 - V_0 C_2$

$$\Rightarrow \quad V_0 = \frac{2C_1}{C_2}\left(V_{in} - \frac{V_{ref}}{2}\right)$$

Q3: ϕ_1: $-V_{in}(C_1 + C_2)$

ϕ_2: $-V_0 C_1$

$$V_{in}(C_1 + C_2) = V_0 C_1$$

$$\Rightarrow \quad V_0 = \left(1 + \frac{C_2}{C_1}\right) \cdot V_{in}.$$