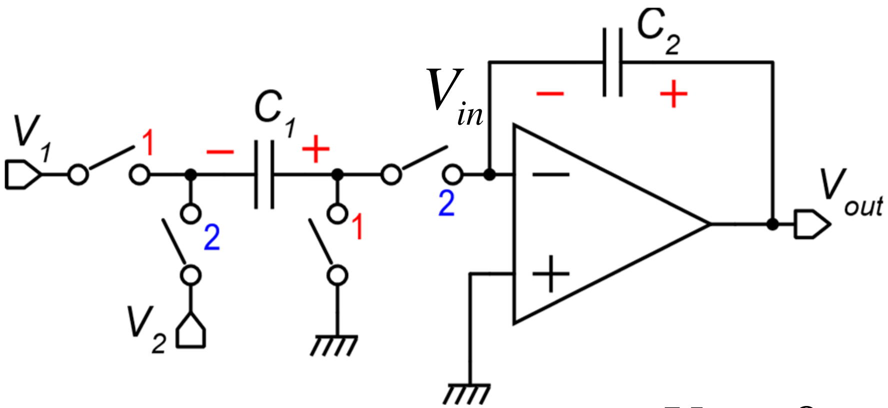
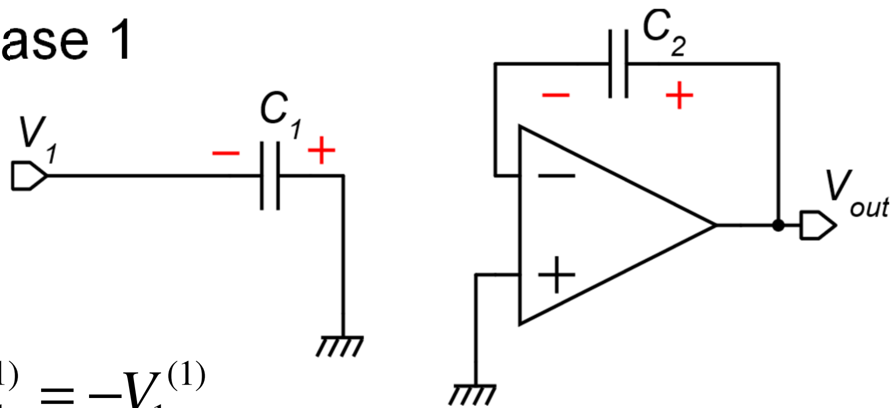
Parasitic insensitive SC integrator



$$V_{in} = 0$$

Phase 1

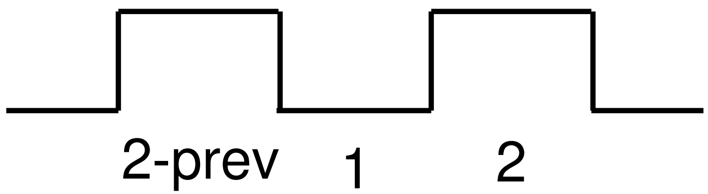


$$V_{C1}^{(1)} = -V_1^{(1)}$$

$$V_{C2}^{(1)} = V_{C2}^{(2-prev)}$$

Simplifying hypotheses: $V_{out} = V_{C2}$

- No offset / noise
- Perfect virtual short circuit
- No charge injection



Parasitic insensitive SC integrator

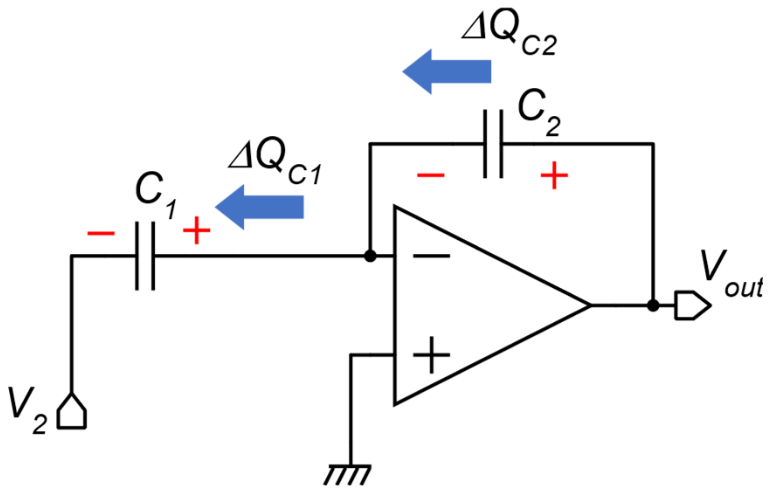
Phase 2 $V_{C1}^{(2)} = -V_2^{(2)}$

$$V_{out}^{(2)} = V_{C2}^{(2)} = V_{C2}^{(1)} + \frac{\Delta Q_{C2}}{C_2} = V_{out}^{(2-prev)} + \frac{\Delta Q_{C2}}{C_2}$$

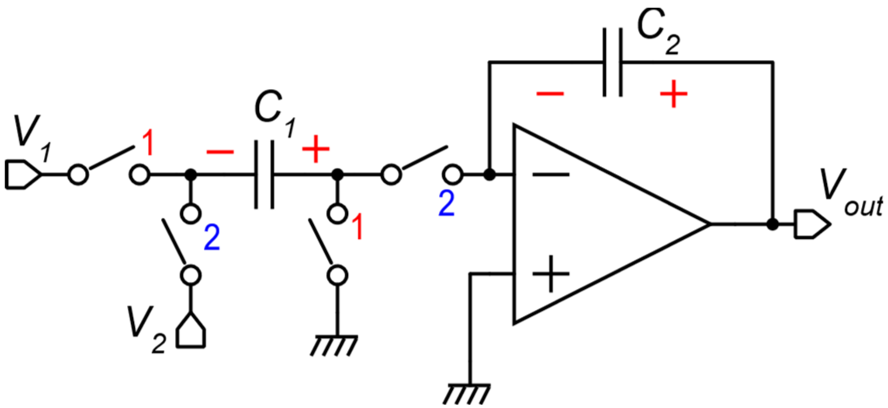
$$\Delta Q_{C2} = \Delta Q_{C1} = C_1\left(V_{C1}^{(2)} - V_{C1}^{(1)}\right)$$

$$\Delta Q_{C2} = C_1\left[-V_2^{(2)} - \left(-V_1^{(1)}\right)\right] = C_1\left(V_1^{(1)} - V_2^{(2)}\right)$$

$$V_{out}^{(2)} = V_{out}^{(2-prev)} + \frac{C_1}{C_2}\left(V_1^{(1)} - V_2^{(2)}\right)$$



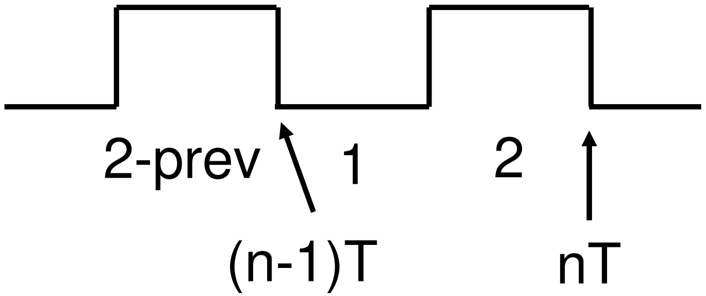
Parasitic insensitive SC integrator



$$V_{out}^{(2)} = V_{out}^{(2-prev)} + \frac{C_1}{C_2}\left(V_1^{(1)} - V_2^{(2)}\right)$$

If we consider that V_1 is sampled at the end of phase 2 and maintained across phase 1:

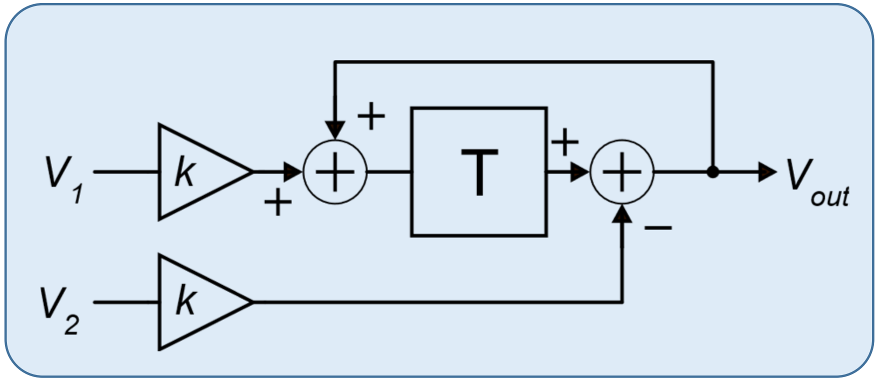
$$V_{out}^{(2)} = V_{out}^{(2-prev)} + \frac{C_1}{C_2}\left(V_1^{(2-prev)} - V_2^{(2)}\right)$$



$$V_{out}(n) = V_{out}(n-1) + \frac{C_1}{C_2}\left[V_1\ (n-1) - V_2\ (n)\right]$$

Block diagram and Z-transform

$$V_{out}(n) = V_{out}(n-1) + \frac{C_1}{C_2}\left[V_1(n-1) - V_2(n)\right]$$



Equivalent block diagram

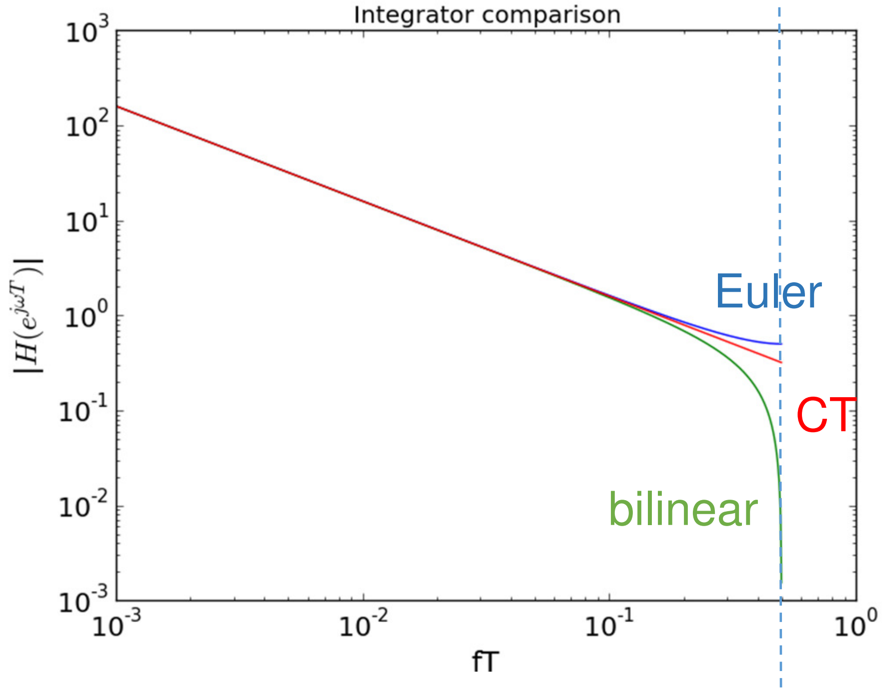
Z-transform

$$V_{out}(z) = V_{out}(z)\,z^{-1} + \frac{C_1}{C_2}\left[V_1(z)\,z^{-1} - V_2(z)\right]$$

$$V_{out}(z) = +\frac{C_1}{C_2}\frac{z^{-1}}{1-z^{-1}}V_1(z) - \frac{C_1}{C_2}\frac{1}{1-z^{-1}}V_2(z)$$

Frequency response

Integrators compared



CT: continuous time integrator

$$V_{out}(z) = +\frac{C_1}{C_2}\frac{z^{-1}}{1-z^{-1}}V_1(z) - \frac{C_1}{C_2}\frac{1}{1-z^{-1}}V_2(z)$$

$$H_1(z) = \left.\frac{V_{out}(z)}{V_1(z)}\right|_{V_2=0} = \frac{C_1}{C_2}\frac{z^{-1}}{1-z^{-1}}$$ Forward Euler Integrator

$$H_2(z) = \left.\frac{V_{out}(z)}{V_2(z)}\right|_{V_1=0} = -\frac{C_1}{C_2}\frac{1}{1-z^{-1}}$$ Backward Euler Integrator

$$\left|H_1\left(e^{j\omega T}\right)\right| = \left|H_2\left(e^{j\omega T}\right)\right|$$