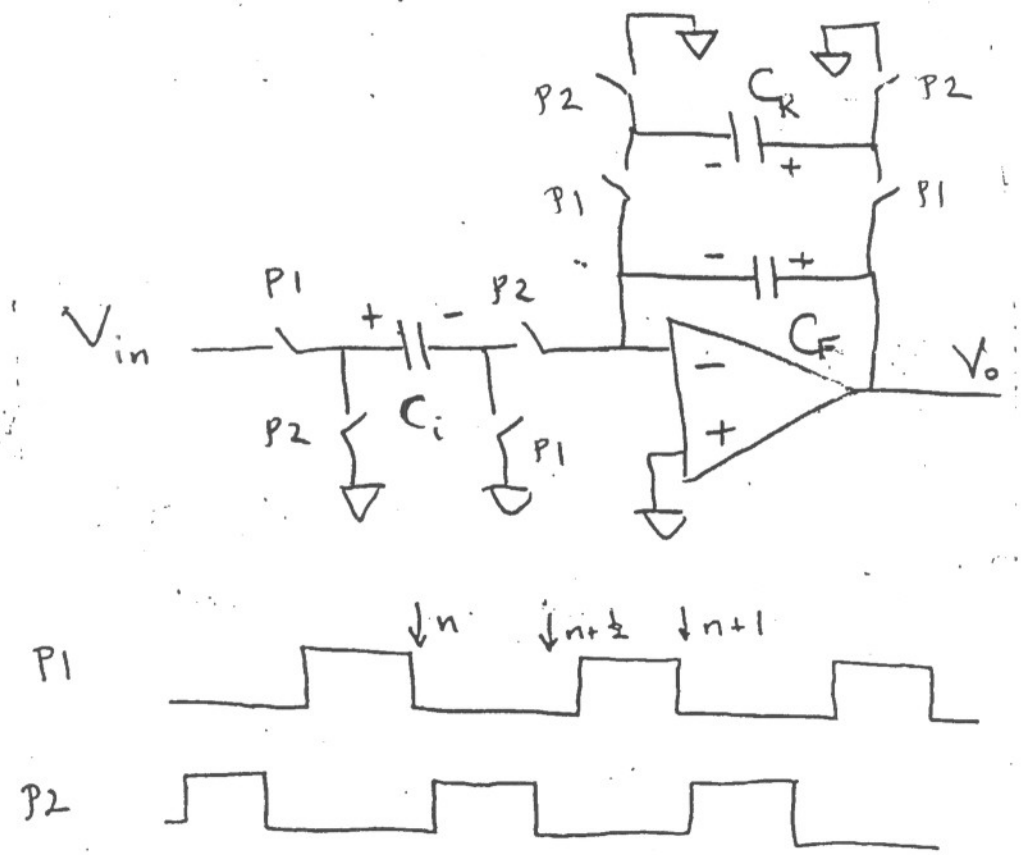
Charge Transfer Analysis of SC Circuits Using Gaussian Surfaces

Idea: Find Gaussian surfaces which are valid for each clock phase. KEY: Charge inside the Gaussian surface must remain constant.



Step 1: Label voltages on caps (+, - signs).

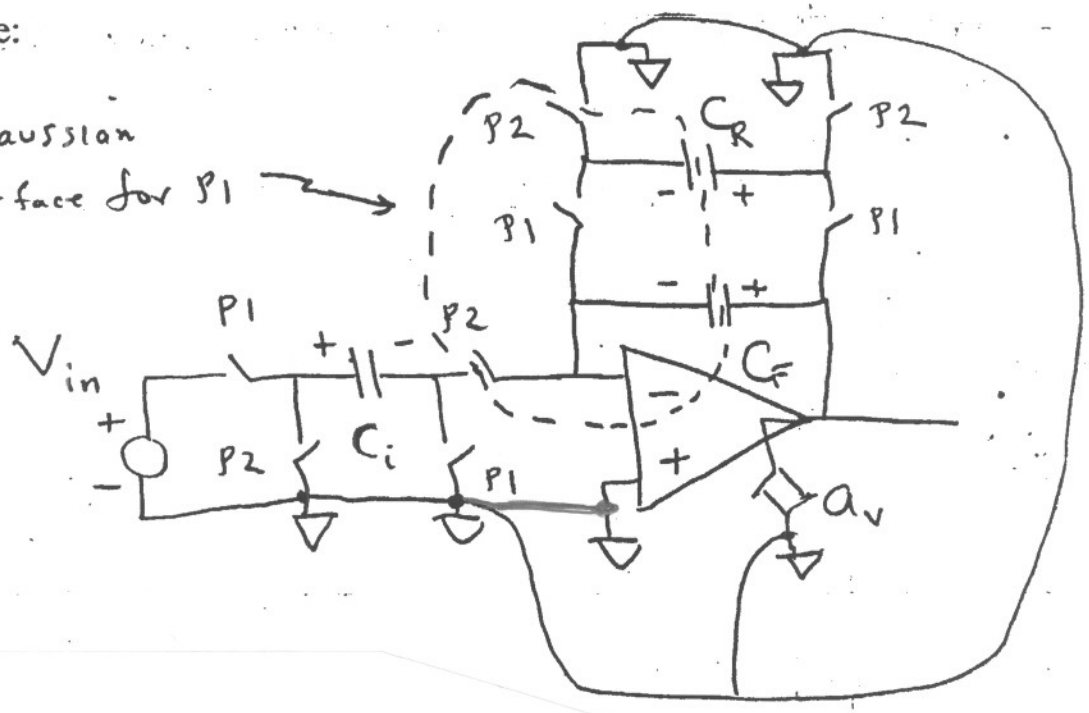
Step 2: Find a Gaussian surface including (-) input of op amp that is valid from non-overlap time (when P1 and P2 low ⇒ all switches are open) to end of clock phase (when P1 or P2 high).

Step 3: Write charge balance equations using the Gaussian surface.

Use Q = CV to get voltage expressions.

Step 4: Repeat 2 and 3 for next clock phase.

Example:



Analyzing P1, time n+1:

a) When P1 and P2 are low (just before P1 goes high):

$$Q_{surface}(P1 = low, P2 = low) = -Q_F(n+\frac{1}{2}) - Q_R(n+\frac{1}{2})$$

b) When P1 is high (at time n+1):

$$Q_{surface}(P1 = hi, P2 = low) = -Q_F(n+1) - Q_R(n+1)$$

c) Charge in the Gaussian surface is constant:

$$Q_{surface}(P1 = low, P2 = low) = -Q_F(n+\frac{1}{2}) - Q_R(n+\frac{1}{2}) =$$
$$Q_{surface}(P1 = hi, P2 = low) = -Q_F(n+1) - Q_R(n+1)$$

Using the last equation with $Q_R(n+\frac{1}{2}) = 0$ gives the equation:

$$-C_F V_o(n+\frac{1}{2}) = -C_F V_o(n+1) - C_R V_o(n+1)$$