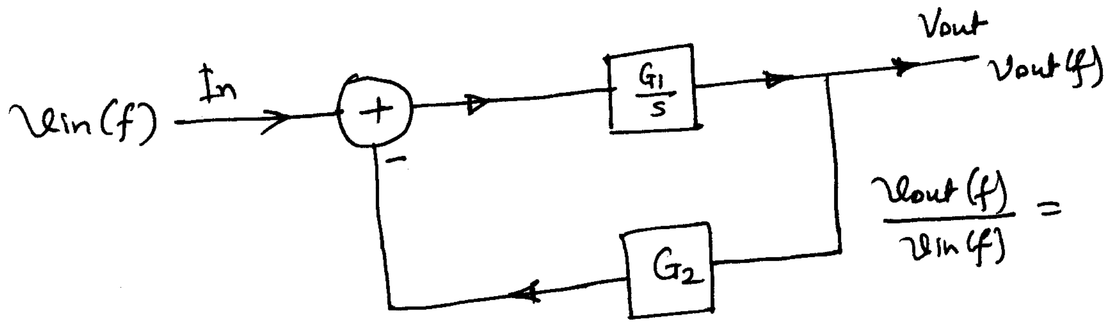
PKirkar@rediffmail.com.

Solution of 35.12 by Pandurang K. Irkar

Prob 35.12 Show the derivation details that result in equations (35.44) and (35.46)

Soln: The general implementation of a lowpass first order filter.



$$\frac{v_{out}(f)}{v_{in}(f)} = \frac{1/G_2}{1 + s/G_1G_2}$$

The schematic diagram of a Discrete Analog Integrator (DAI) (Ref. 31.78)

→ To ~~be~~ begin with (Basically) the output of the DAI is connected to the OPAMP through ϕ_1 switch. When the ϕ_1 switches are closed (ϕ_1 is high) the charge stored on C_I is at n−1 → switches shut off), the charge stored on C_I is

$$Q_1 = C_I\left(V_{cm} - V_1[(n-1)T_s]\right) \quad \text{— (1)}$$

When ϕ_2 switches turn on the charge stored on C_I becomes

$$Q_2 = C_I\left(V_{cm} - V_2[(n-\tfrac{1}{2})T_s]\right) \quad \text{— (2)}$$

The difference ~~#~~ in these charges, $Q_2 - Q_1$ → Resulting in output voltage change. This change can be written as

$$\left(v_{out}[nT_s] - v_{out}[(n-1)T_s]\right)C_F = C_I\left(V_1[(n-1)T_s] - V_2[(n-1/2)]T_s\right) \quad \text{— (3)}$$

Writing in Z-domain results in

$$v_{out}(z)\left(1-z^{-1}\right) = \frac{C_I}{C_F}\left(v_1(z)\cdot z^{-1} - v_2(z)z^{-1/2}\right) \quad \text{(4)}$$

Depending upon the output connected to ϕ_1 or ϕ_2; we have different topologies. and one of them is as shown in following fig.

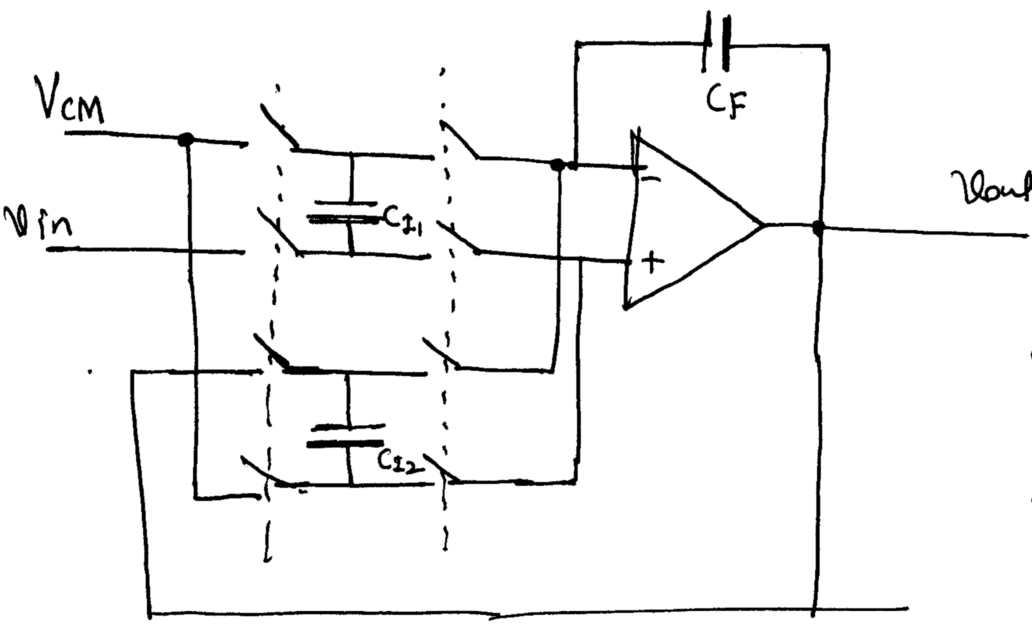
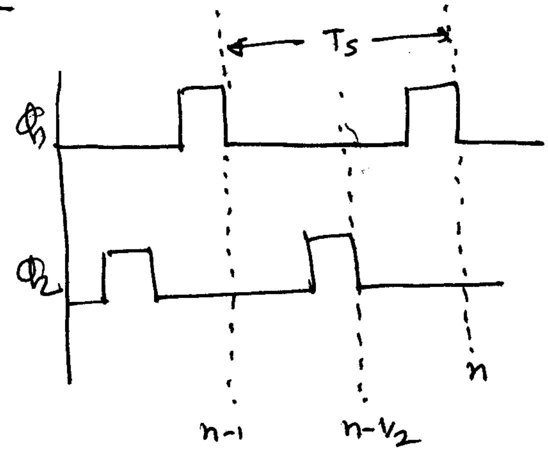


fig (2)



Similarly as above procedure we can write the equation for the ~~abv~~ fig. 2. topology

Begin with ϕ_1 and at n-1 shutting off, we can write

~~Charges~~

$$Q_1 = C_{I_1}\left(V_{CM} - V_{in}\left[(n+\tfrac{1}{2})T_s\right]\right) \quad \text{——} (1)$$

with ~~ϕ_{I2}~~ C_{I2}

$$\phi_1' = C_{I2}\left(V_{out}(n+\tfrac{1}{2})T_s - V_{CM}\right) \quad \text{——} (2)$$

The output change across the feed back capacitor is

$$\left(V_{out}[(nT_s)] - V_{out}[(n-1)T_s]\right)C_F = C_{I_1}\left(V_{CM} - V_{in}(n+\tfrac{1}{2})T_s\right)$$
$$- C_{I2}\left(V_{out}(n+\tfrac{1}{2})T_s - V_{CM}\right)$$

writing into z domain

$$V_{out}(z) = \frac{z^{-1}}{1-z^{-1}}$$

$$V_{out}(z)\,(1-z^{-1})C_F = C_{I1}\left(V_{in}(z)z^{1/2} - C_{I2}\,(V_{out}(z))\right)$$

$$V_{out}(z) = \frac{z^{-1}}{1-z^{-1}}\cdot\left[\frac{C_{I1}}{C_F}\cdot V_{in}(z)\cdot z^{1/2} - \frac{C_{I2}}{C_F}\cdot V_{out}(z)\right]$$

With this equation we can write for general Block diagram

$$G_1 = \frac{C_{I1}}{C_F}\cdot f_s \quad \text{and} \quad G_2 = \frac{C_{I2}}{C_f}\cdot f_s\cdot\frac{1}{G_1} = \frac{C_{I2}}{C_{I1}}$$

$$f_{3dB} = \frac{G_1 G_2}{2\pi}$$