Problem: 12.30

\[
(V/W)_1 = (V/W)_2 = \frac{15}{15 + 10 + 10} = \frac{3}{5}
\]

\[
V_{in} = \frac{1}{2} \left( V_{out} + V_{out} \right) = \frac{V_{out}}{2}
\]

Thus, the charging of \( C_2 \) on an average will be given by a time constant \( \tau = \frac{C_2}{V_{in}} \).

Assuming that \( V_{in} = 3V \), \( V_{out} = 0.7V \).

Initially, when \( CK \) goes high, \( C_1 \) gets charged to \( V_{in} = 2V \).

When \( CK \) goes low, \( M_1 \) is ON and charge is shared between \( C_1 \) and \( C_2 \). Since, \( C_1 = C_2 \), \( V_x = V_{out} = 1V \). When \( CK \) goes high, \( M_2 \) is OFF. \( M_2 \) turns ON and \( C_1 \) again charges to 2V.

When \( CK \) goes low, \( V_x = V_{out} = \frac{2C_1 + 2C_2}{C_1 + C_2} = 1.5V \), and so on.

If \( M_1, M_2 \) are identical, when \( CK = 1 \) to 0, \( CK = 0 \) to 1, there will be an error in voltage at \( V_x \) since both the clock feedthrough will cancel off.

When \( CK = 0 \) to 1, there will be some feedthrough to \( V_{out} \), which we undo when \( CK = 1 \) to 0 at the end of the cycle.

Hence, the feedthrough does not affect the output voltage in steady state. Hence, no error is introduced in the op because of feedthrough.

Charge injection: When \( CK \) goes low, \( M_2 \) goes on. The worst case will be when all the charge in the inversion layer go towards the right. Error in \( V_x \) due to this will be \( (V/W)_1 \times (V_{out} - V_{in} - V_{in}) \times 1 \).

Corresponding error at the output will be half of this value.

When \( M_2 \) goes off, the channel charge splits equally between \( C_1 \) and \( C_2 \). However, in order to turn ON, \( M_2 \) would have taken that same amount of charge from \( C_1, C_2 \) which it gives back when it goes OFF. Hence, channel charge from \( M_2 \) does not cause any error in output.

Hence, total error in the output from charge injection is only due in \( M_1 \). Thus, max. error = \( \frac{(V/W)_1 \times (V_{out} - V_{in} - V_{in})}{2C_1} \).

Max. total error in output = \( \frac{(V/W)_1 \times (V_{out} - V_{in} - V_{in})}{2C_1} \).

When \( M_2 \) is ON, rms noise voltage at \( V_x \) is given as \( V_{in} \).

\[
V_{in} = \frac{V_{th}}{\tau C_1} \sqrt{\frac{2e^2}{C_1}} = \sqrt{\frac{KT}{C_1}}
\]

Half of this noise voltage will appear at the output when \( M_2 \) is ON.

When \( M_2 \) is ON,

\[
\frac{V_{out}}{V_{in}} - \frac{V_{th}}{C_1} = \frac{V_{out}}{C_2}
\]
Problem 12.11

\[ V_{in} = V_0 \sin(\omega t + \phi) \]

\[ V_{out} = V_0 \sin(\omega t + \phi) \]

\[ f = 2 \pi \times 10^{10} \text{ Hz} \]

The total noise power at output

\[ P_{out} = \left( \frac{20}{\pi} \right) \frac{V_{in}^2}{T} + \frac{4V^2}{\pi^2 T} \]

\[ V_{out} = \frac{V_{in}}{1 + \frac{C}{T} + \frac{1}{Cfrq}} \]

The total output voltage is given by

\[ V_{out} = \frac{V_{in}}{1 + \frac{C}{T} + \frac{1}{Cfrq}} \]
Problem 12.15

\[ C_1 = C_2 = 1 \text{ pF} \]
\[ f_{\text{in}} = 100 \text{ MHz} \]
\[ \text{Vin} = 0.5 \cos(2\pi(100 \text{ MHz})t) \]

\[ \text{S}_1, \text{S}_2 \text{ and } C_1 \text{ form a resistor of value } R = \frac{1}{R_{\text{in}} C_1} = 10 \text{K}\Omega \]

\[ \text{Vin} = \frac{-1}{R_{\text{in}} C_1} \int \text{Vin} \, dt \]
\[ \text{Vout} = \frac{-1}{R_{\text{in}}} \int 0.5 \cos(2\pi(100 \text{ MHz})t) \, dt \]
\[ = -0.5 \times \frac{\sin[2\pi(100 \text{ MHz})t]}{2\pi(100 \text{ MHz})} \times 10 \text{K}\Omega \]

Hence, o/p amplitude = 0.796 V.
When $S_0$ turns on, $V_{ref}$ = $a$, i.e., $V_{out}$ changes overall from $V_a$ to $a$.

Hence, $V_{out}$ will change from $a$ + $\Delta V_{out}$ to $\{a, V_a + \Delta V_{out}\}$.

where $\Delta V_{out}$ is only an offset.