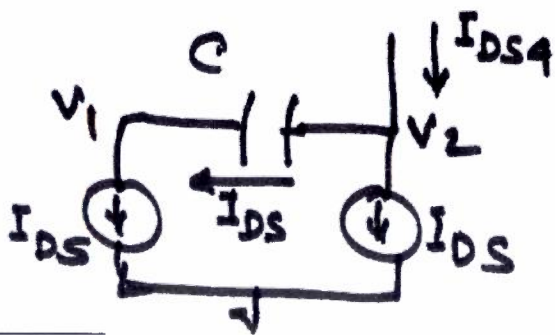


① If M3 is OFF & M4 ~~are~~ IS ON

Then $V_{out} = V_{DD} - V_{TNM3} - V_{TN4} = V_{DD} - 2V_{TN}$

Then no current goes through M3. But M4 must provide $2I_{DS}$ current, as it must cater to

I_{DS2} & I_{DS1} currents. I_{DS1} comes through charging of Capacitor C.



Case 2

Now if M3 is ON and M4 is OFF
Then $\overline{V_{out}}$ will be similar to that
of V_{out} as in case 1.

Hence V_1 and V_2 will alternate in
time frame.

Since I_{Ds} charges capacitor in time Δt , hence delivered
charge in capacitor $C = I_{Ds} \cdot \Delta t$

However capacitor sees change of $\bullet V_{DD} - V_{TN} - V_{DD} - 3V_{TN}$
 $= 2V_{TN}$

\therefore charge in capacitor $= C \cdot 2V_{TN}$

$\therefore \Delta t = \frac{2CV_{TN}}{I_{Ds}}$. But Frequency $f = \frac{1}{2\Delta t} = \frac{I_{Ds}}{4CV_{TN}}$



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Current Starved VCO

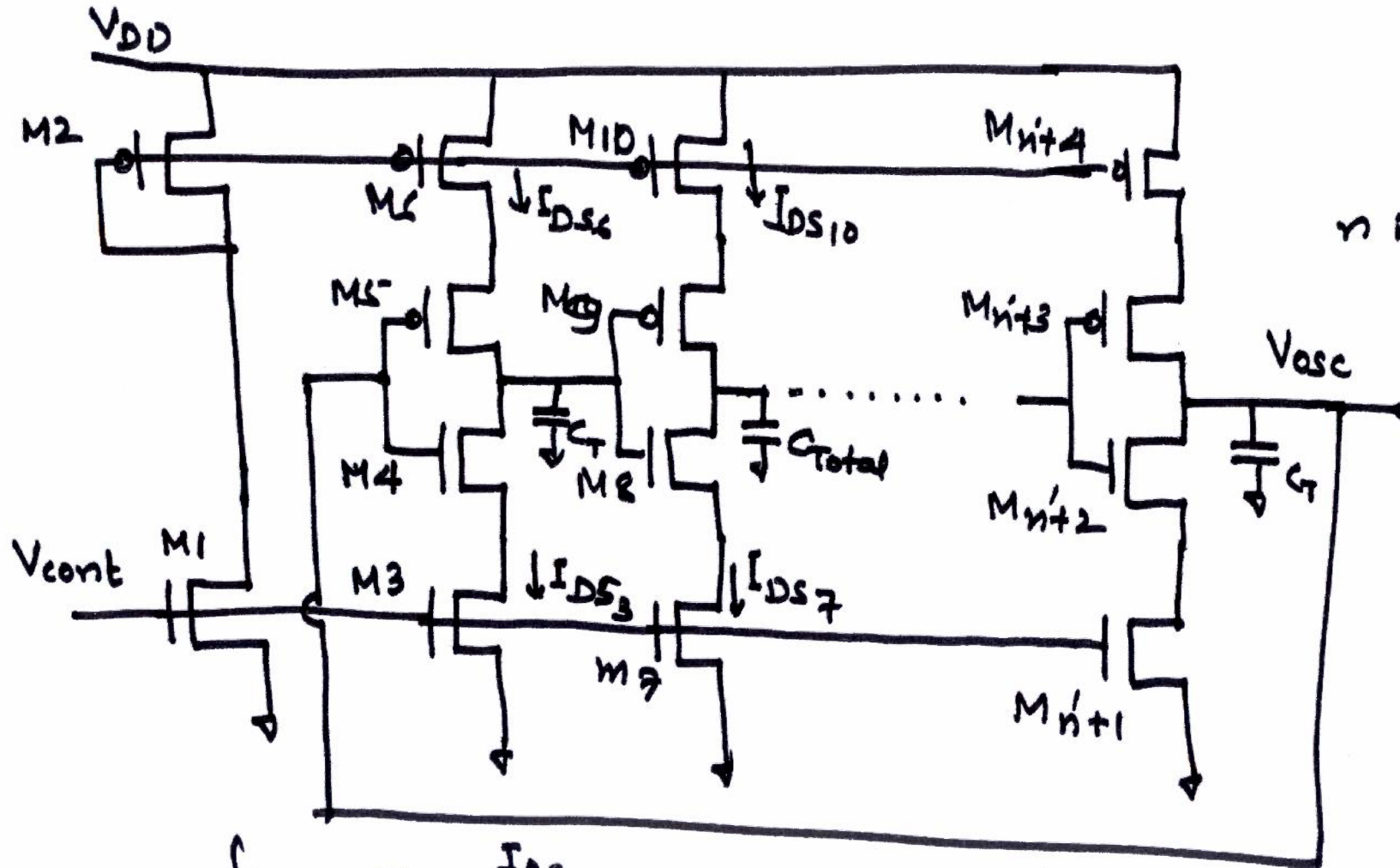
This is essentially a Ring Oscillator



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n is no. of Column.



$$f_{osc} = \frac{I_{DS}}{N \cdot C_{Total} \cdot V_{DD}}$$