

Analog Lab

Experiment 4: Charge Pump

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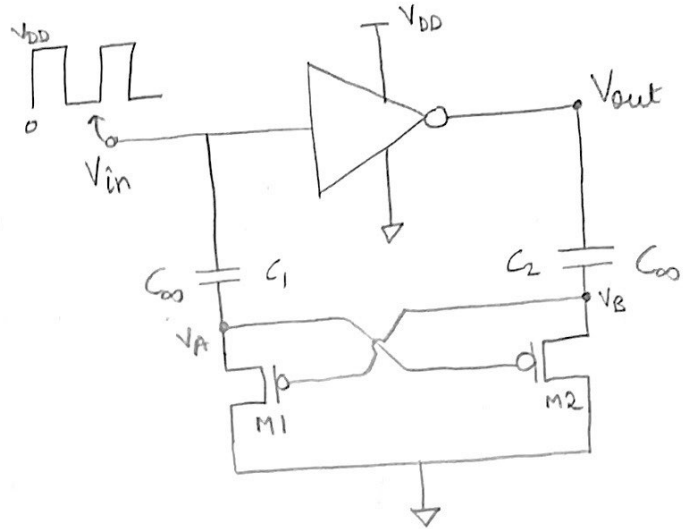
Roll - EE20BTECH11042

1) Initially the charge on capacitors are 0 so they act as short circuits.

when $V_{in} = V_{DD}$,

$$V_A = V_{DD} \quad \& \quad V_B = 0$$

(due to inverter)

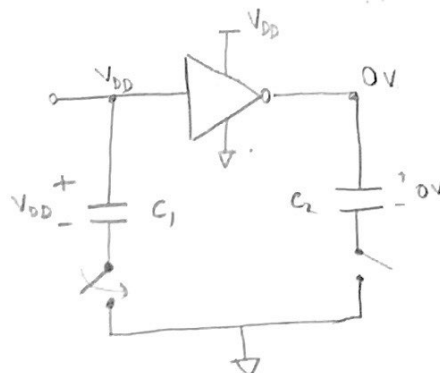


So V_{GS} for M1, $V_{GS} = V_B - V_A = -V_{DD}$

V_{GS} for M2, $V_{GS} = V_A - V_B = V_{DD}$

So M1 acts as a closed switch and M2 acts as an open switch. Because of this, C_1 gets charged to V_{DD} volts.

So the circuit becomes -



After the capacitor is charged instantaneously,

$$V_A = 0V$$

$$V_B = 0V$$

Now when $V_{in} = 0V$ -

$$V_A = V_{in} - V_{C1} = 0 - V_{DD} = -V_{DD}$$

$$V_B = V_{out} - V_{C2} = V_{DD} - 0 = V_{DD} \quad (V_{out} = V_{DD} \text{ due to CMOS})$$

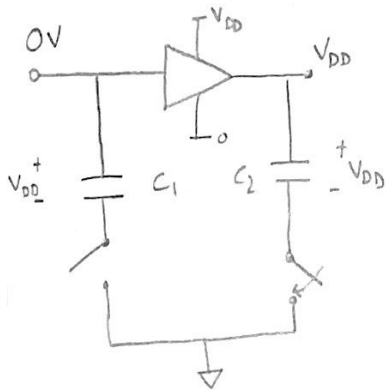
$$\text{So } V_{GS} \text{ for } M1, V_{GS} = V_B - V_A = 2V_{DD}$$

$$V_{GS} \text{ for } M2, V_{GS} = V_A - V_B = -2V_{DD}$$

M1 acts as open switch and M2 acts as closed switch.

Due to that, C2 gets charged to V_{DD}

The circuit becomes -



As soon as C2 gets charged to V_{DD} , V_B becomes $0V$.

$$\text{So, } V_A = -V_{DD}, V_B = 0V$$

Now when $V_{in} = V_{DD}$ -

$$V_A = V_{in} - V_{C1} = V_{DD} - V_{DD} = 0V$$

$$V_B = V_{out} - V_{C2} = 0 - V_{DD} = -V_{DD}$$

$$\text{So } V_{GS} \text{ for } M1, V_{GS} = V_B - V_A = -V_{DD} \Rightarrow \text{Closed switch}$$

$$V_{GS} \text{ for } M2, V_{GS} = V_A - V_B = V_{DD} \Rightarrow \text{Open switch}$$

Now when $V_{in} = 0V$ -

$$V_A = V_{in} - V_{C1} = 0 - V_{DD} = -V_{DD}$$

$$V_B = V_{out} - V_{C2} = V_{DD} - V_{DD} = 0V$$

So V_{GS} for M1, $V_{GS} = V_B - V_A = +V_{DD} \Rightarrow$ Open switch

V_{GS} for M2, $V_{GS} = V_A - V_B = -V_{DD} \Rightarrow$ Closed switch

Following the pattern, we get the graphs as -

