Digital Electronics Project:

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Parameters:

$Kp' = 10\ \mu A/V^2$

$Kn' = 35\ \mu A/V^2$

$T_{pd} = 2ns$

$C_L = 4pF$

Part 2:

171000841

Parameters

$K_p' = 10$

$K_n' = 35$

$T_{PD} = 2\,nS$

$C_L = 4\,pF$

Part 2:

T_{LH} : 0V → 2.5

$$V_{DSP(avg)} = \frac{(5-0)+(5-2.5)}{2} = 3.75V$$

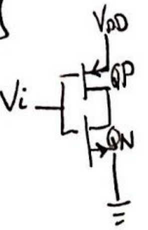
$V_{GSP} = 5V$

$V_{TP} = -1V$

$3.75 < 5-1$ ∴ ohmic

$$I_{DSP} = K_p'(W_P/L_P)\left[(5-1)3.75 - 3.75^2/2\right]$$

$$I_{DSP} = K_p'(W_P/L_P)\left[7.96875\right]$$



$$I = \frac{C\Delta V}{\Delta T}$$

$$I_{DSP(avg)} = \frac{(4pF)(2.5)}{2nS}$$

$$\frac{(4pF)(2.5)}{2nS} = (10)(W_P/L_P)(7.96875)$$

$$\frac{4pF(2.5)}{2nS(10\,uA/V^2)(7.96875)} = \left[W_P/L_P\right] = \left[W_P/1\right] = \boxed{\begin{matrix}62.745\ um \\ L_P = 1\end{matrix}}$$

T_{HL} 5V → 2.5V

$$V_{DSN(avg)} = \frac{(5-0)+(5-2.5)}{2} = 3.75V$$

$$I_{DSN(avg)} = K_n'(W_N/L_N)\left[(5-1)3.75 - (3.75^2/2)\right] = K_n'(W_N/L_N)7.96875$$

$$I_{DSN(avg)} = \frac{(4pF)(2.5)}{2nS} = K_n'(W_N/L_N)7.96875$$

Answers:

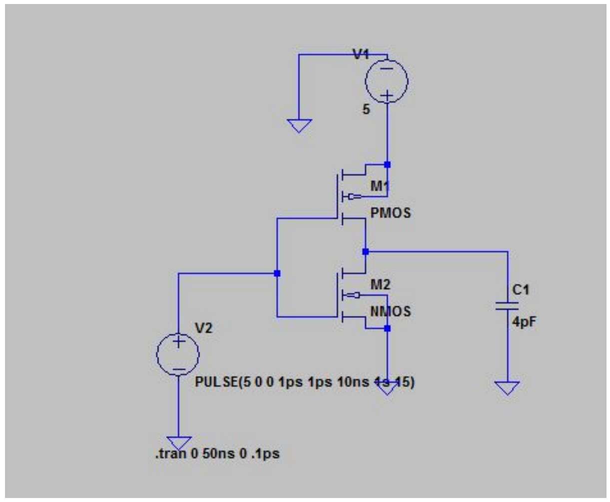
$$\frac{W_P}{L_P} = \frac{62.745}{1}$$

$$\frac{W_N}{L_N} = \frac{17.927}{1}$$

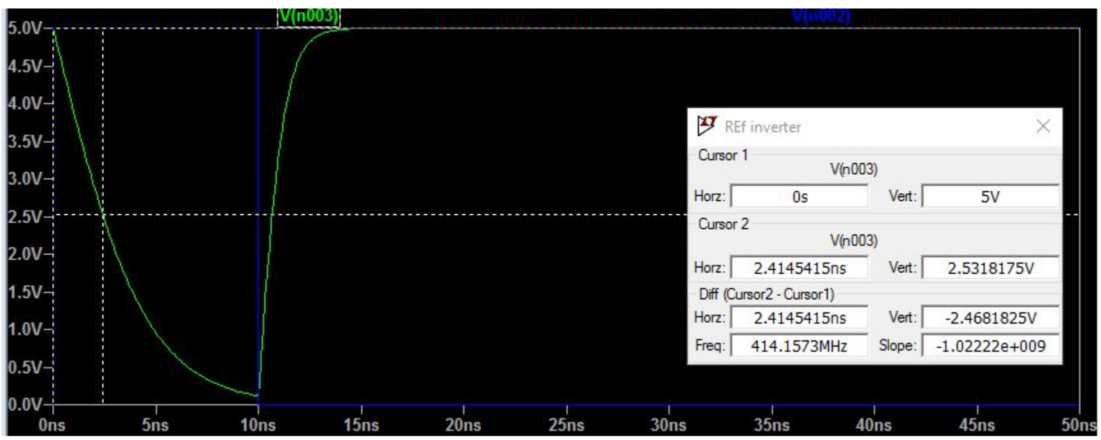
$$\frac{(4pF)(2.5)}{2nS(35\,uA/V^2)(7.96875)} = \left[W_N/L_N\right] \rightarrow \left[\frac{W_N}{1}\right] = \boxed{\begin{matrix}17.927\,um \\ L_N = 1\end{matrix}}$$

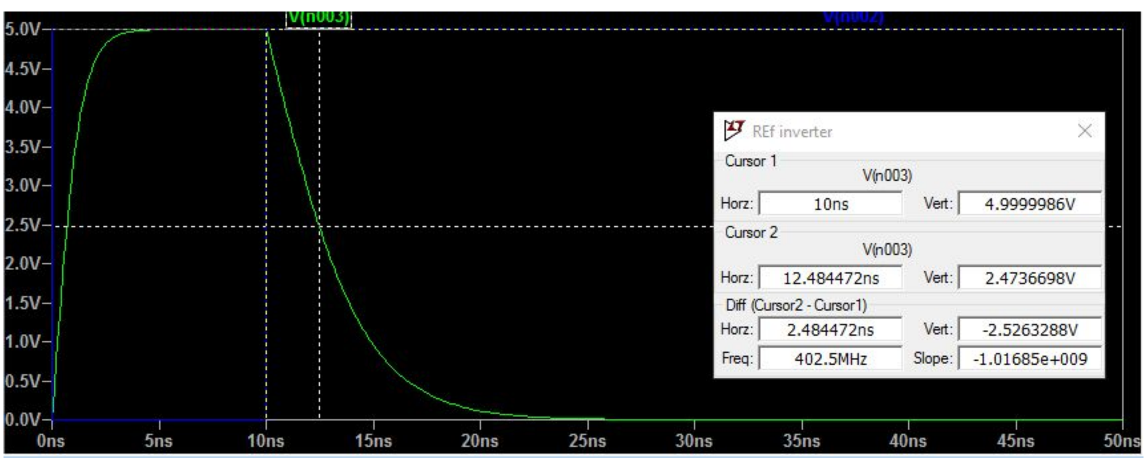
Part 3:

Circuit:



Rise and Fall Times:





$$T_{PD}=(T_{PDLH}+T_{PDHL})/2=((2.48ns+2.41ns))/2 \cong 2.40ns$$

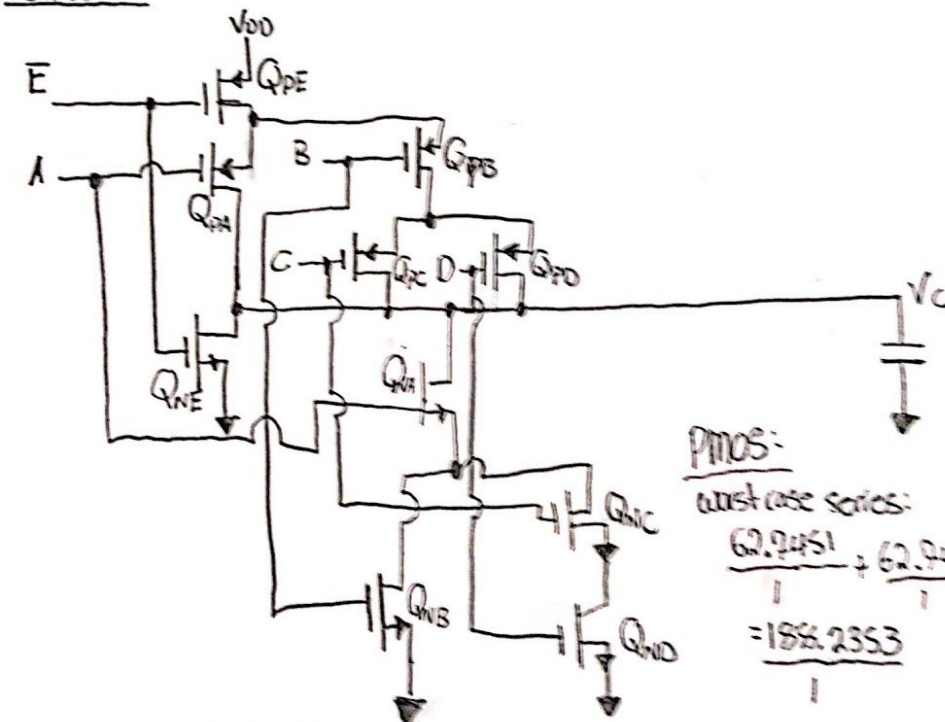
Comparing this value of T_{PD} with the 2ns we can see that they fall within a reasonable margin of error.

Part 4:

Part 4:

$$Y = [A(B+CD)+E]$$
$$= (A(B+CD))'E'$$
$$= (A'+(B+CD)')E'$$
$$= (A'+B'(CD)')E'$$
$$= (A'+B'(C'+D'))E'$$
$$\boxed{Y = (A'+B'[C'+D'])E'}$$

circuit:



PMOS:

worst case series:

$$\frac{62.7451}{1} + \frac{62.7451}{1} + \frac{62.7451}{1}$$
$$= \frac{188.2353}{1}$$

so:

$$\boxed{\begin{aligned} Q_{PE} = Q_{PB} = Q_{PC} = Q_{PD} &= \frac{188.2353}{1} \\ Q_{PA} &= \frac{188.2353}{2} \end{aligned}}$$

Nmos:

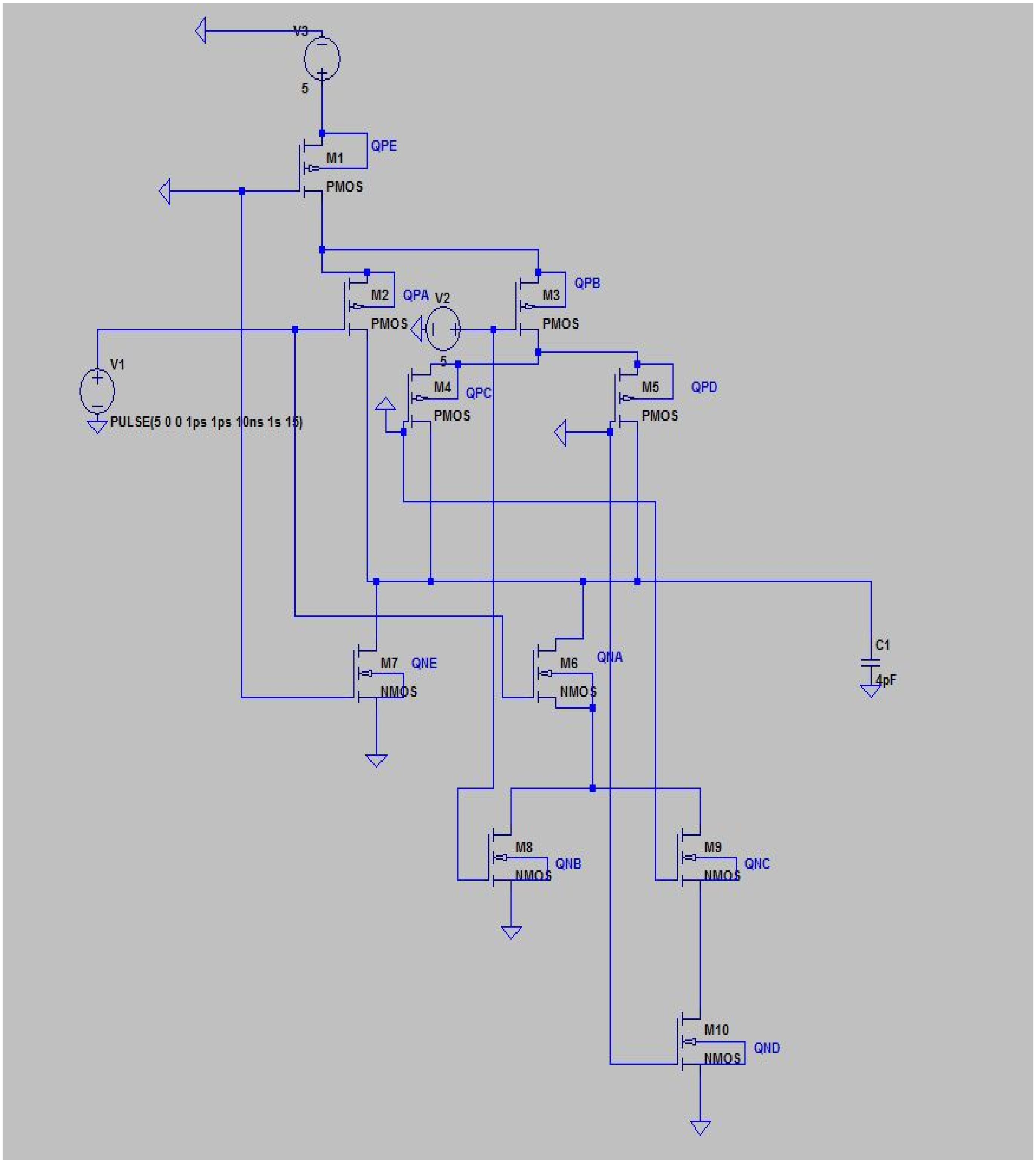
$$\frac{17.927}{1} + \frac{17.927}{1} + \frac{17.927}{1} = \frac{53.781}{1}$$

$$Q_{NA} = Q_{NC} = Q_{ND} = \frac{53.781}{1}$$

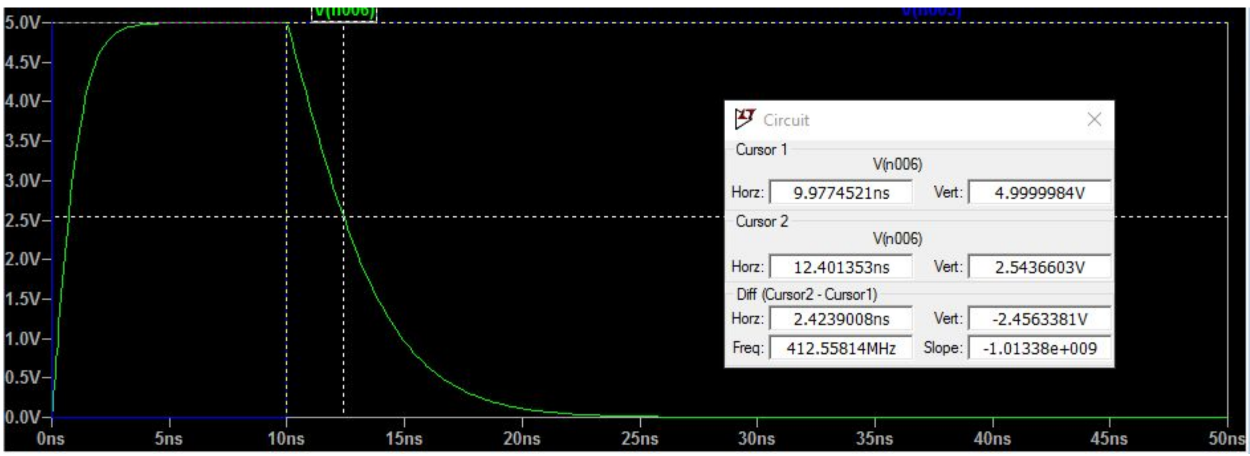
$$Q_{NB} = \frac{53.781}{2} \qquad Q_{NE} = \frac{53.781}{3}$$

Part 5:

Circuit:



Rise and Fall Times:



$$T_{PD}=(T_{PDLH}+T_{PDHL})/2=((2.40+2.40)/2=2.40\text{ns}$$

Comparing this value of T_{PD} with the 2ns we can see that they fall within a reasonable margin of error.

Part 6:

Part6: Minimum Area Design:

Qn worst case:

$$\frac{W_N}{L_N} = \frac{17.927}{1} \longrightarrow \frac{17.927}{1} + \frac{17.927}{1} = \frac{17.927}{2}$$

all Q's are going to $\frac{17.927}{1}$

$$T_{PDHL1} = \frac{\frac{17.927}{1}}{\frac{17.927}{2}} (T_{PHL}) = 2(2ns) = \boxed{4ns}$$

Qp worst case:

$$\frac{W_P}{L_P} = \frac{17.927}{1} + \frac{17.927}{1} = \frac{17.927}{2}$$

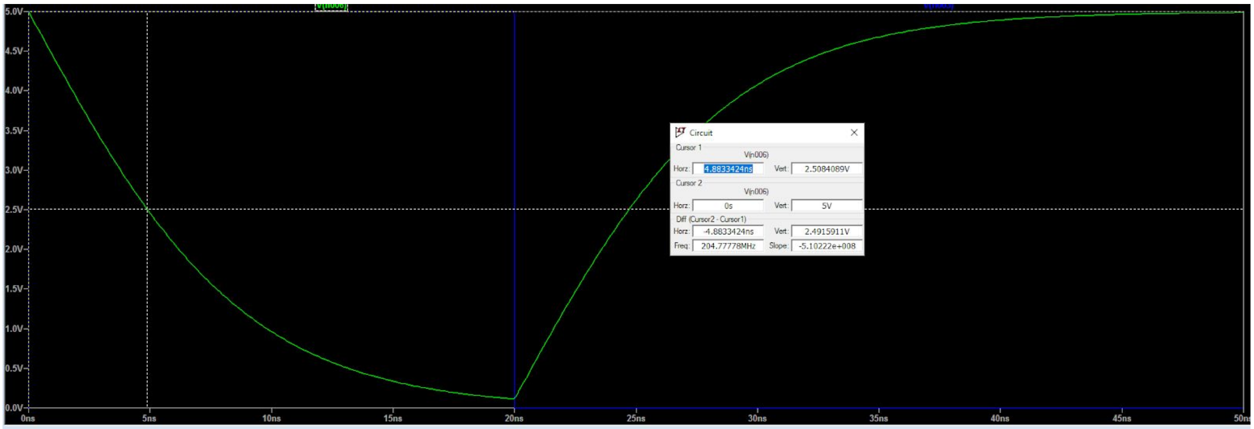
$$T_{PDLH1} = \left[\frac{\frac{62.7451}{1}}{\frac{17.927}{2}}\right] \cdot T_{PDLH} = 7(2n) = \boxed{14nS}$$

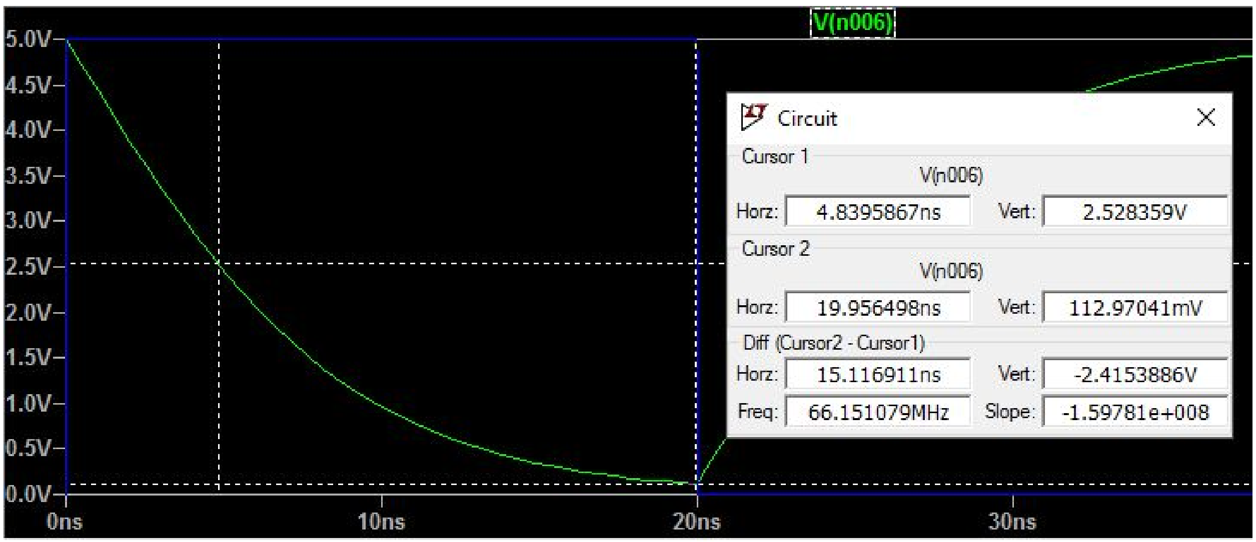
$$T_{PD1} = \frac{14nS + 4ns}{2} = 9ns$$

$$T_{PD} = T_{PD1}/2ns = 9nS/2ns = 4.5$$

- In min design T_{PD1} is 4.5 times slower than orginal

WaveForms:





$$T_{PD*} = (T_{PDLH*} + T_{PDHL*})/2 = ((15.1\text{ns} + 4.80) / 2 \cong 9.5 \text{ ns}$$

Comparing this value of T_{PD} with the 9ns we can see that they fall within a reasonable margin of error.