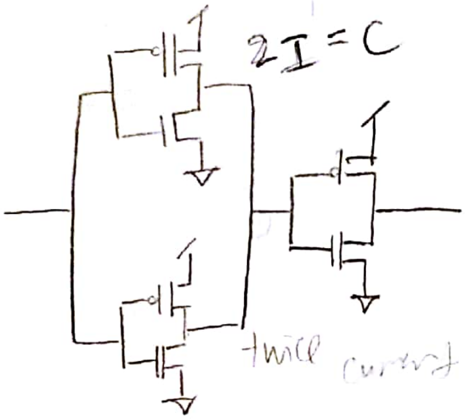
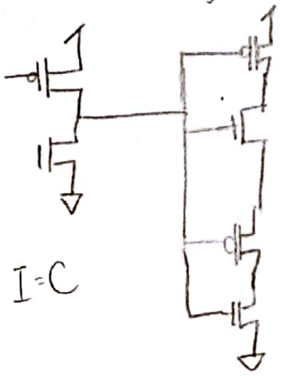
Colleen Lay
Feb 9, 2018
EE 307 HW5

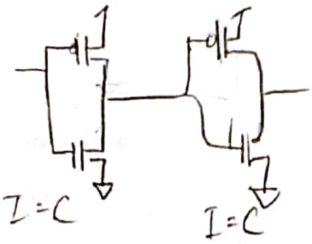
1.
a) Circuit 1



Circuit 2 2I=C



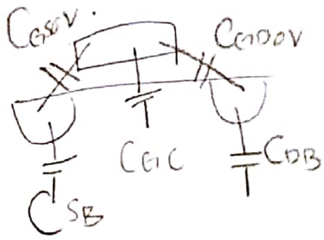
Circuit 2



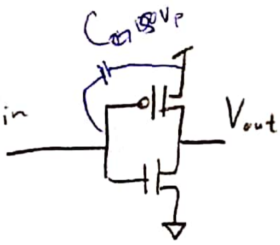
$\tau = 2 \times N \times t_p$

1.a) Circuit 1 fastest
Circuit 2 midde speed
Circuit 3 slowest

less cap = faster



b)



Circuit 4

$C = C_{GSOVP} + C_{GCP} + 2C_{GDOVP}$ gate
$+ C_{GSOVN} + C_{GCN} + 2C_{GDOVN}$

c) capacitance on
NMOS gate $CGC + CGS_{ov} + CGD_{ov} = C_{ox} \cdot W_N \, L_N + C_{GSO} \cdot W_N + C_{GDO} \cdot W_N$

$= (0.00432)(0.3 \times 10^{-6} m)(100 \times 10^{-6} m)$
$+ (3.4 \times 10^{-10})(0.3 \times 10^{-6} m)$
$+ (3.4 \times 10^{-10})(0.3 \times 10^{-6} m)$

$C_{ox} = E0 \cdot \frac{Er}{tox}$
$= (8.854 \times 10^{-12} F/m)\left(\frac{3.9}{8 \times 10^{-9}}\right)$

$\boxed{C_{ox} = 0.00432}$

Cap on NMOS gate $= 1.298 \times 10^{-13}$ F

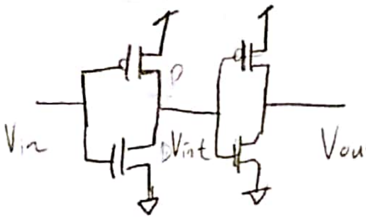
PMOS gate $CGC + CGS_{ov} + CGD_{ov} = C_{ox} \, W_P \, L_P + C_{GSO} \cdot W + C_{GDO} \cdot W$
$tox_P = 8 \times 10^{-9}$

$= (0.00432)(2 \times 10^{-6} m)(100 \times 10^{-6} m)$
$+ (5.3752 \times 10^{-11})(2 \times 10^{-6})$
$+ (5.3752 \times 10^{-11})(2 \times 10^{-6})$

Cap on PMOS gate $= 8.6421 \times 10^{-13}$ F

Vin cap $= C_P + C_N = 9.939 \times 10^{-13}$F

1. d)



$$C = \left.\begin{array}{l} C_{GSOVP} + C_{GCP} + 2C_{GDOVP} \\ + C_{GSOVN} + C_{GCN} + 2C_{GD'OVN} \end{array}\right] = C_{part\,C}$$

$$+ C_{GDOVP} + C_{DBP}$$

$$+ C_{GDOVN} + C_{DBN}$$

$+$

e) $C = C_{part\,C} + (C_{ox} W_P L_P + C_{DBOP} \cdot W_P) + (C_{ox} W_N L_N + C_{DBON} \cdot W_N)$

C_{ox} 8.64×10^{-13} 6.73×10^{-10}

e) $= C_{part\,C} + (0.00432)(2 \times 10^{-6} m)(100 \times 10^{-6} m) + (3.365 \times 10^{-10}) \times (2 \times 10^{-6})$

$+ (0.00432)(0.3 \times 10^{-6} m)(100 \times 10^{-6} m) + (5.75 \times 10^{-10})(0.3 \times 10^{-6})$

1.29×10^{-13} 1.725

$= 1.988 \times 10^{-12} F$

f) Area (M2) $116\ aF/\mu m^2$

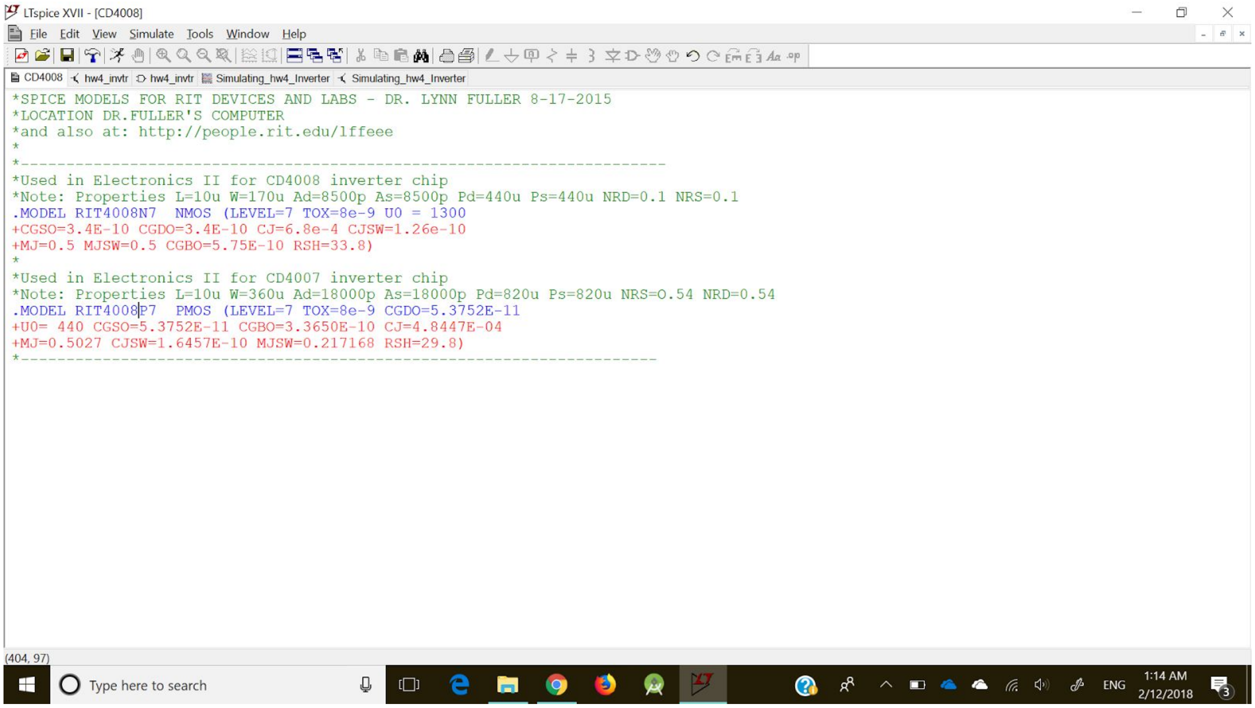
$20\mu = L$
$2\mu = W$

$C = \text{Area} \times C_{\text{per unit area}}$
$= (20\mu m)(2\mu m)(116\ aF/\mu m^2)$

$\boxed{C = 4640 aF}$

2a) $T = 2 \times N \times t_P$; $t_P = \frac{t_r + t_f}{2}$
$= 2 \times 17 \times \left(\frac{(0.05 + 0.12) \times 10^{-9}}{2}\right)$
$= 2.89 \times 10^{-9} sec$

Scanned by CamScanner

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*SPICE MODELS FOR RIT DEVICES AND LABS - DR. LYNN FULLER 8-17-2015
*LOCATION DR.FULLER'S COMPUTER
*and also at: http://people.rit.edu/lffeee
*
*------------------------------------------------------------------------
*Used in Electronics II for CD4008 inverter chip
*Note: Properties L=10u W=170u Ad=8500p As=8500p Pd=440u Ps=440u NRD=0.1 NRS=0.1
.MODEL RIT4008N7  NMOS (LEVEL=7 TOX=8e-9 U0 = 1300
+CGSO=3.4E-10 CGDO=3.4E-10 CJ=6.8e-4 CJSW=1.26e-10
+MJ=0.5 MJSW=0.5 CGBO=5.75E-10 RSH=33.8)
*
*Used in Electronics II for CD4007 inverter chip
*Note: Properties L=10u W=360u Ad=18000p As=18000p Pd=820u Ps=820u NRS=0.54 NRD=0.54
.MODEL RIT4008P7  PMOS (LEVEL=7 TOX=8e-9 CGDO=5.3752E-11
+U0= 440 CGSO=5.3752E-11 CGBO=3.3650E-10 CJ=4.8447E-04
+MJ=0.5027 CJSW=1.6457E-10 MJSW=0.217168 RSH=29.8)
*-----------------------------------------------------------------------
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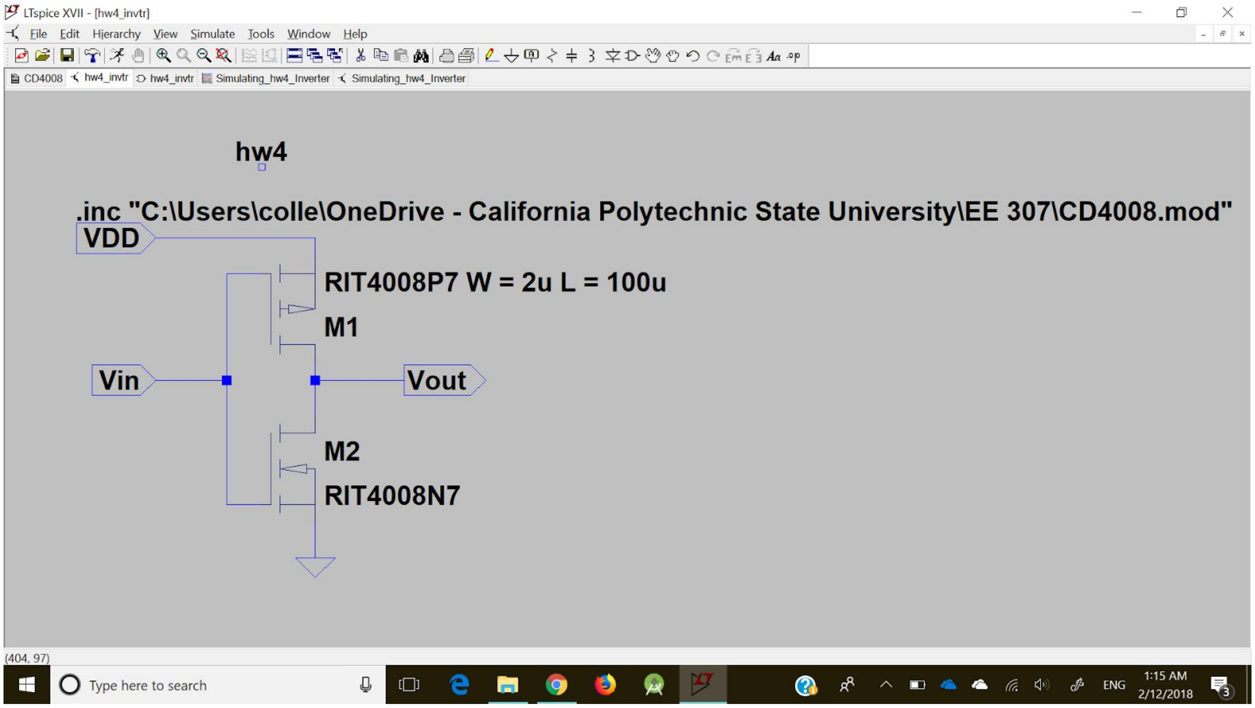
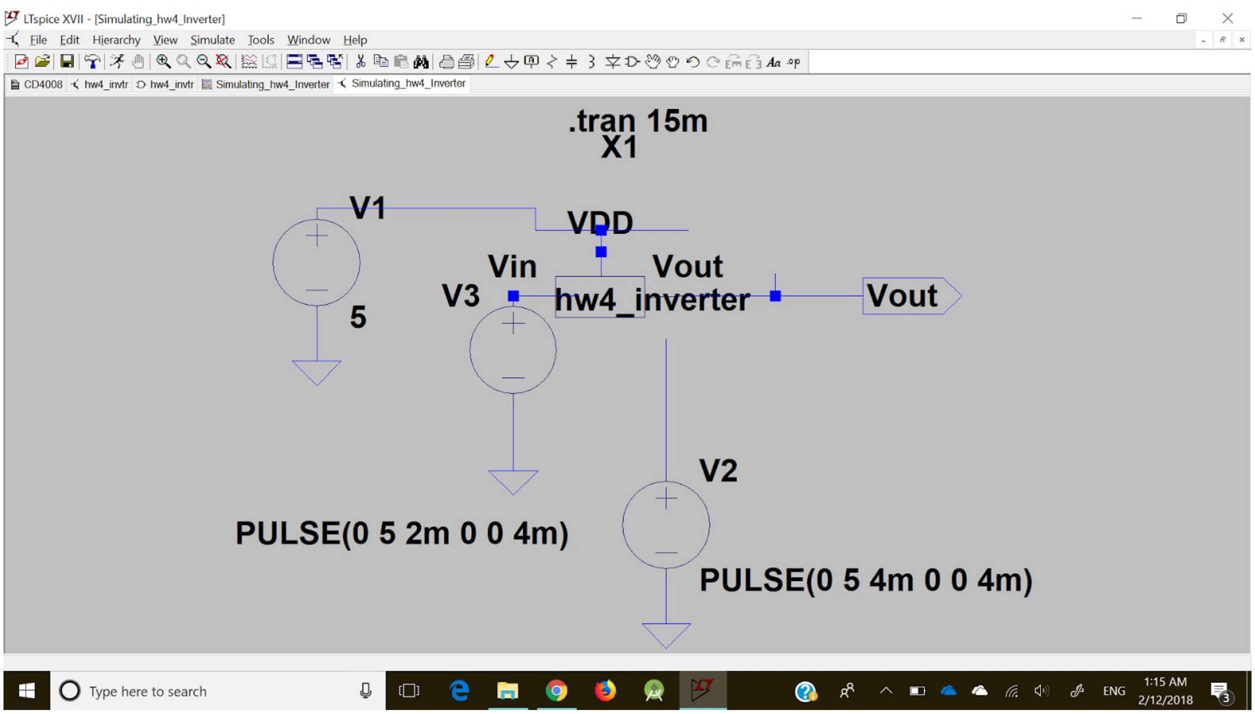
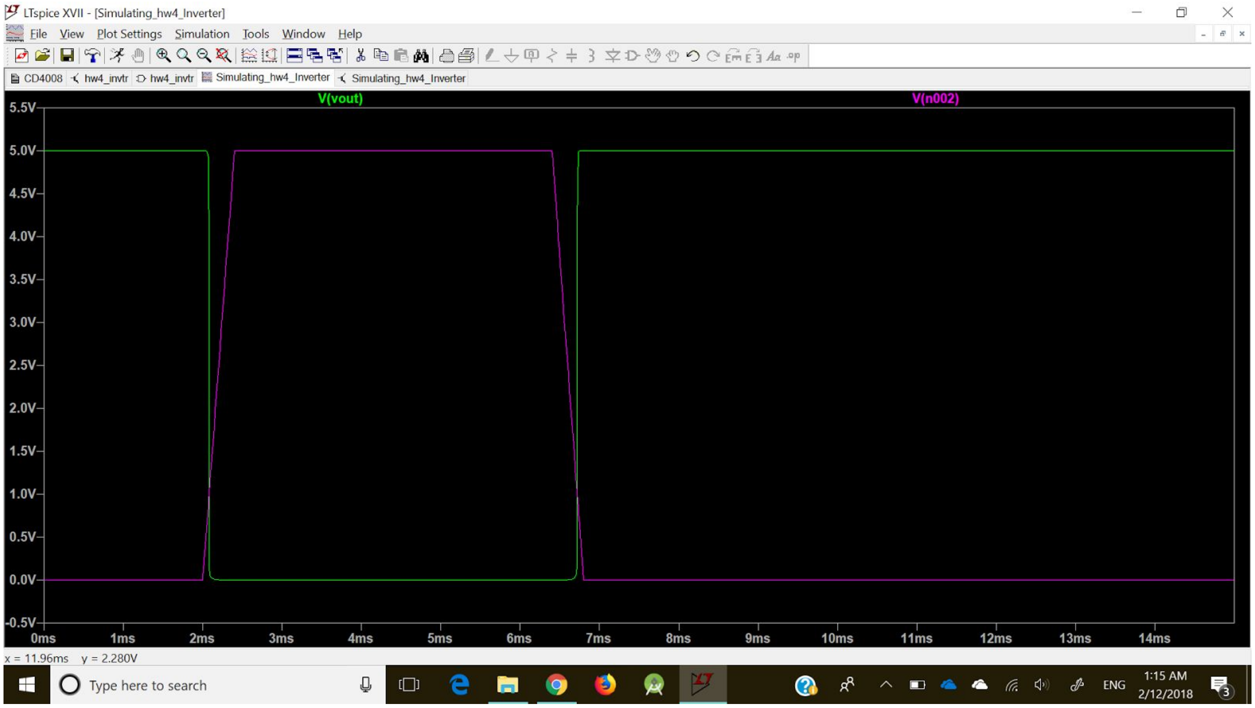

LTspice XVII - [hw4_invtr]
File Edit Hierarchy View Simulate Tools Window Help
CD4008
hw4_invtr
hw4_invtr
Simulating_hw4_Inverter
Simulating_hw4_Inverter
hw4
.inc "C:\Users\colle\OneDrive - California Polytechnic State University\EE 307\CD4008.mod"
VDD
RIT4008P7 W = 2u L = 100u
M1
Vin
Vout
M2
RIT4008N7
(404, 97)
Type here to search
ENG
1:15 AM
2/12/2018


LTspice XVII - [Simulating_hw4_Inverter]
File Edit Hierarchy View Simulate Tools Window Help
CD4008
hw4_invtr
hw4_invtr
Simulating_hw4_Inverter
Simulating_hw4_Inverter
.tran 15m
X1
V1
VDD
Vin
Vout
V3
hw4_inverter
Vout
5
V2
PULSE(0 5 2m 0 0 4m)
PULSE(0 5 4m 0 0 4m)
Type here to search
ENG
1:15 AM
2/12/2018


LTspice XVII - [Simulating_hw4_Inverter]
File View Plot Settings Simulation Tools Window Help
CD4008 hw4_invtr hw4_invtr Simulating_hw4_Inverter Simulating_hw4_Inverter
V(vout)
V(n002)
5.5V
5.0V
4.5V
4.0V
3.5V
3.0V
2.5V
2.0V
1.5V
1.0V
0.5V
0.0V
-0.5V
0ms 1ms 2ms 3ms 4ms 5ms 6ms 7ms 8ms 9ms 10ms 11ms 12ms 13ms 14ms
x = 11.96ms y = 2.280V
Type here to search
ENG
1:15 AM
2/12/2018