Design Exercise 5

IECE420/520/ICSI522: Introduction to VLSI

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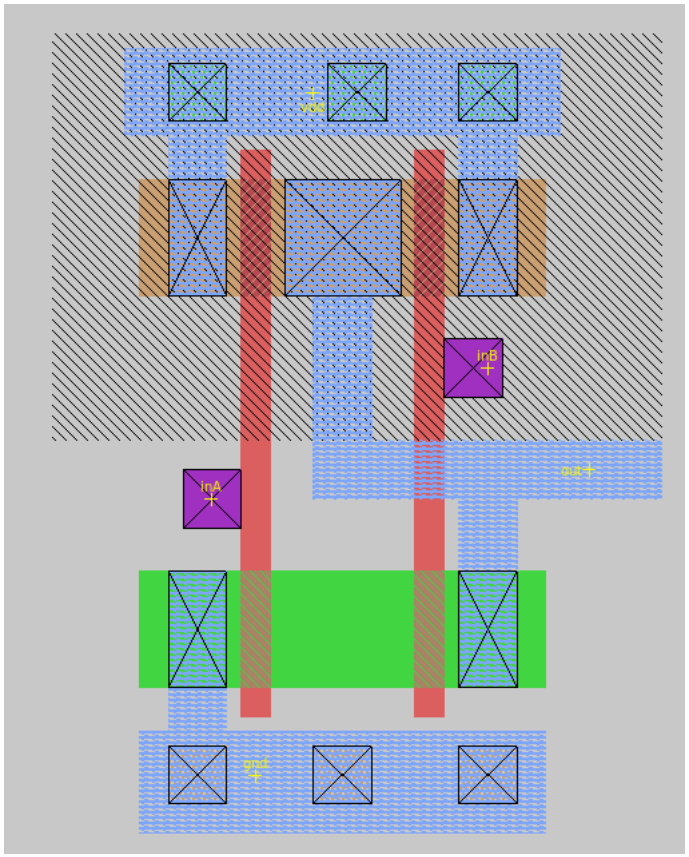
Questions

$2\lambda = 0.18\mu$, $L_{min} = 2\lambda$, $W_{min} = 4\lambda$

1. Draw a 2-input NAND gate (size transistors to match the unit inverter) using MAGIC, make sure it passes all DRCs, extract the circuit level netlist, simulate using SPICE and compare tp_{HL} for AB = 00 -> 11 with DE-2 (3 points)

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* SPICE3 file created from two_in_nand.ext - technology: scmos

.option scale=0.09u
.include MagicNames.txt

Vdd vdd 0 dc 1.8

VG1 inA 0 pulse(0 1.8 10p 10p 10p 300p 600p)
VG2 inB 0 pulse(0 1.8 10p 10p 10p 300p 600p)


M1000 vdd inB out vdd pfet w=8 l=2
+  ad=112 pd=60 as=80 ps=36
M1001 out inB a_n10_n7# Gnd nfet w=8 l=2
+  ad=56 pd=30 as=80 ps=36
M1002 out inA vdd vdd pfet w=8 l=2
+  ad=0 pd=0 as=0 ps=0
M1003 a_n10_n7# inA gnd Gnd nfet w=8 l=2
+  ad=0 pd=0 as=56 ps=30


.measure tran tphl trig v(inA) val=0.9 rise=3 targ v(out) val=0.9 fall=3

.tran 1p 3000p
.control
Run
Plot inB inA out
.endc
.end

*C0 vdd inB 5.47fF
*C1 vdd inA 3.57fF
*C2 gnd Gnd 9.59fF
*C3 out Gnd 4.32fF
*C4 inB Gnd 3.81fF
*C5 inA Gnd 6.18fF
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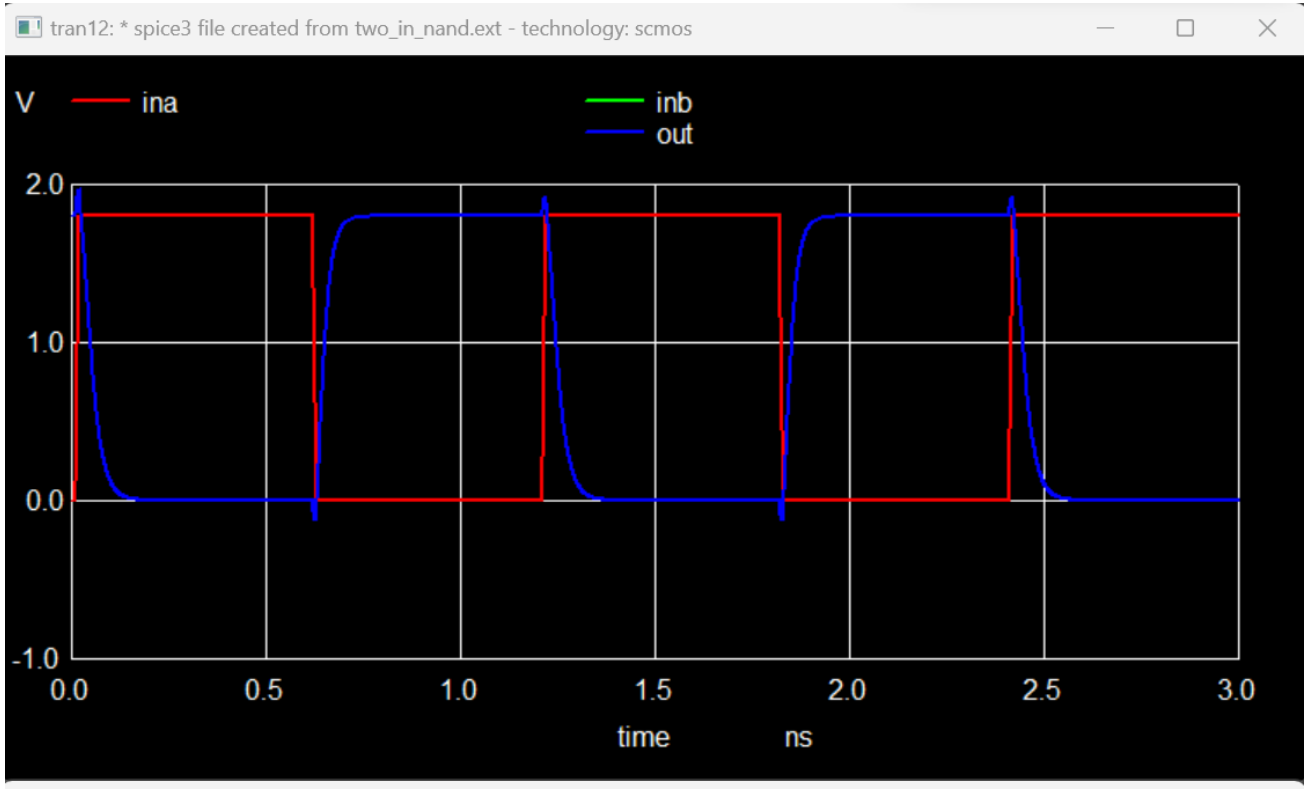
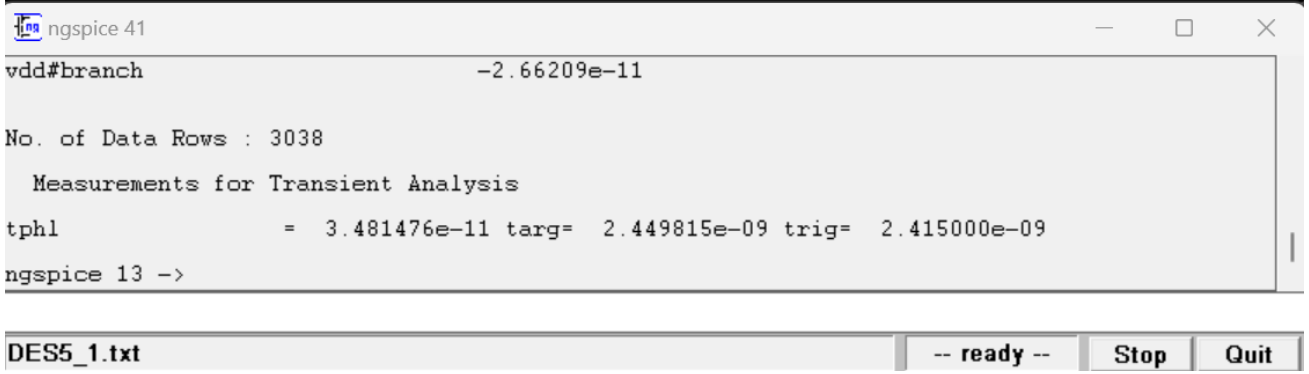
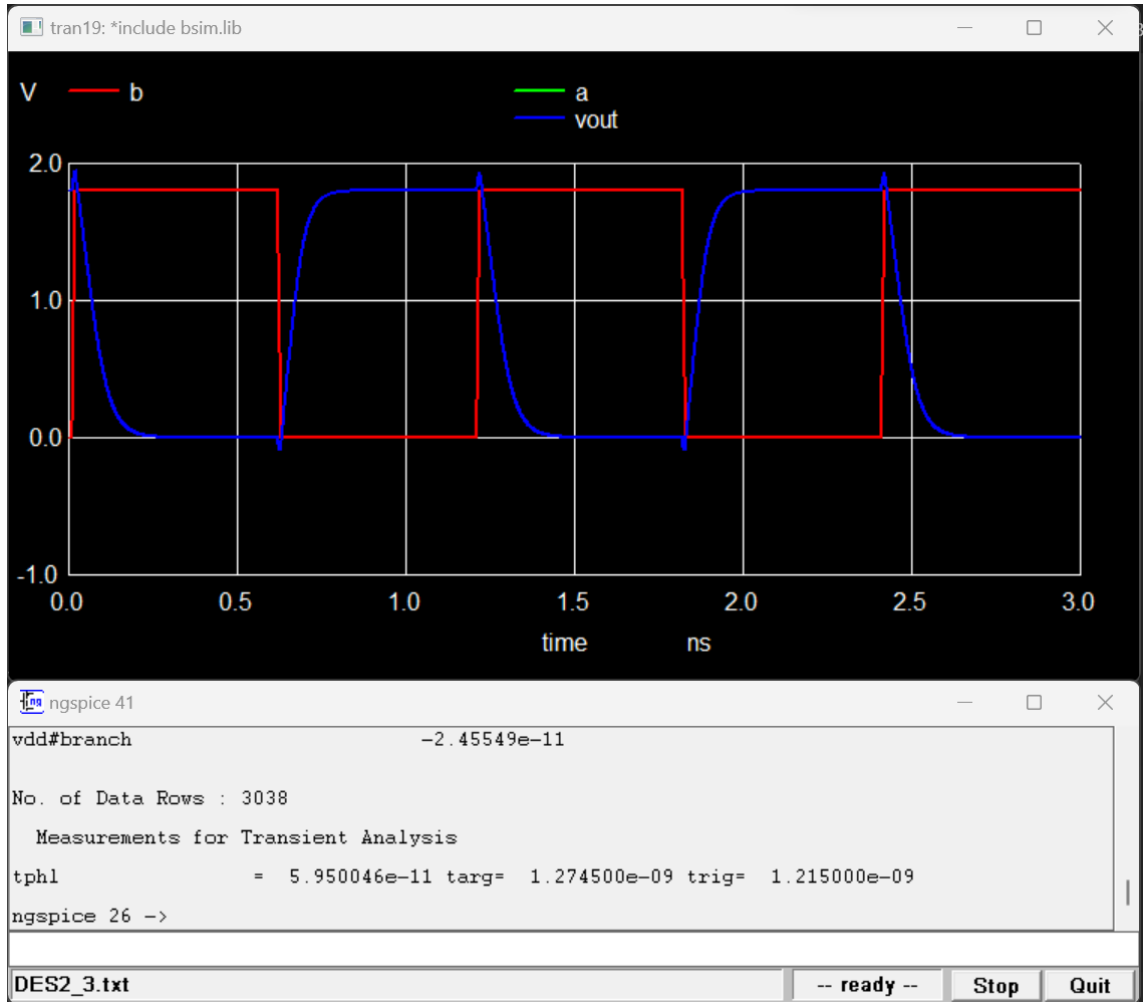




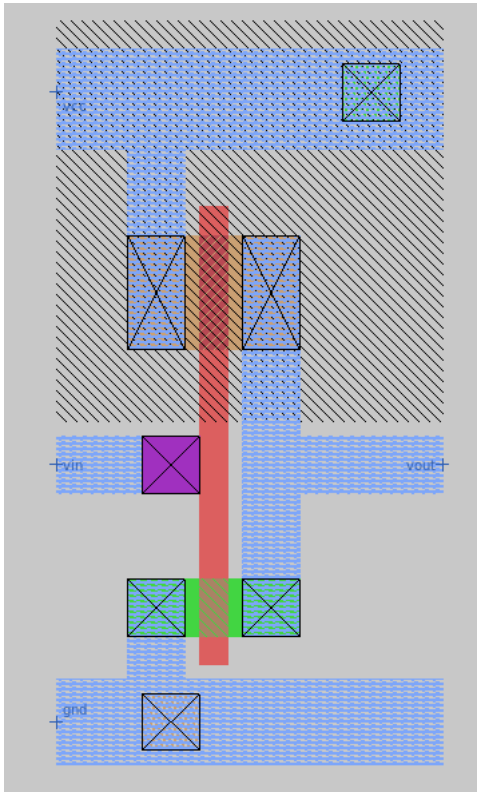
With Magic tplh = 3.48e-11 sec



Without Magic : tplh = 5.95e-11

Des2 has bigger tplh

2. Draw a 11-stage ring oscillator (RO) using MAGIC, make sure it passes all DRCs, and extract the circuit level netlist. (2 points)

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* SPICE3 file created from DES_5_2.ext - technology: scmos

.option scale=1u

.global Vdd Gnd

.subckt invertor a_n1_0# a_6_0# w_n6_15# a_0_10#
M1000 a_6_0# a_0_10# a_n1_0# Gnd nfet w=4 l=2
+  ad=20 pd=18 as=20 ps=18
M1001 a_6_0# a_0_10# w_n6_15# w_n6_15# pfet w=8 l=2
+  ad=40 pd=26 as=40 ps=26
C0 w_n6_15# a_0_10# 2.15fF
C1 a_n1_0# Gnd 7.43fF
C2 a_6_0# Gnd 3.95fF
C3 a_0_10# Gnd 5.97fF
.ends


* Top level circuit DES_5_2

Xinvertor_10 gnd vout vcc invertor_9/a_6_0# invertor
Xinvertor_0 gnd invertor_0/a_6_0# vcc vout invertor
Xinvertor_1 gnd invertor_1/a_6_0# vcc invertor_0/a_6_0# invertor
Xinvertor_2 gnd invertor_2/a_6_0# vcc invertor_1/a_6_0# invertor
Xinvertor_4 gnd invertor_4/a_6_0# vcc invertor_3/a_6_0# invertor
Xinvertor_3 gnd invertor_3/a_6_0# vcc invertor_2/a_6_0# invertor
Xinvertor_5 gnd invertor_5/a_6_0# vcc invertor_4/a_6_0# invertor
Xinvertor_6 gnd invertor_6/a_6_0# vcc invertor_5/a_6_0# invertor
Xinvertor_7 gnd invertor_7/a_6_0# vcc invertor_6/a_6_0# invertor
Xinvertor_8 gnd invertor_8/a_6_0# vcc invertor_7/a_6_0# invertor
Xinvertor_9 gnd invertor_9/a_6_0# vcc invertor_8/a_6_0# invertor
C0 invertor_1/a_6_0# vout 4.47fF
C1 vout invertor_0/a_6_0# 4.47fF
C2 vout invertor_9/a_6_0# 4.47fF
C3 vout invertor_7/a_6_0# 4.47fF
C4 vout invertor_4/a_6_0# 4.47fF
C5 vout invertor_6/a_6_0# 4.47fF
C6 vout invertor_2/a_6_0# 4.47fF
C7 vout invertor_5/a_6_0# 4.47fF
C8 invertor_3/a_6_0# vout 4.47fF
C9 vout invertor_8/a_6_0# 4.47fF
C10 gnd Gnd 23.02fF
C11 vout Gnd 24.08fF
.end
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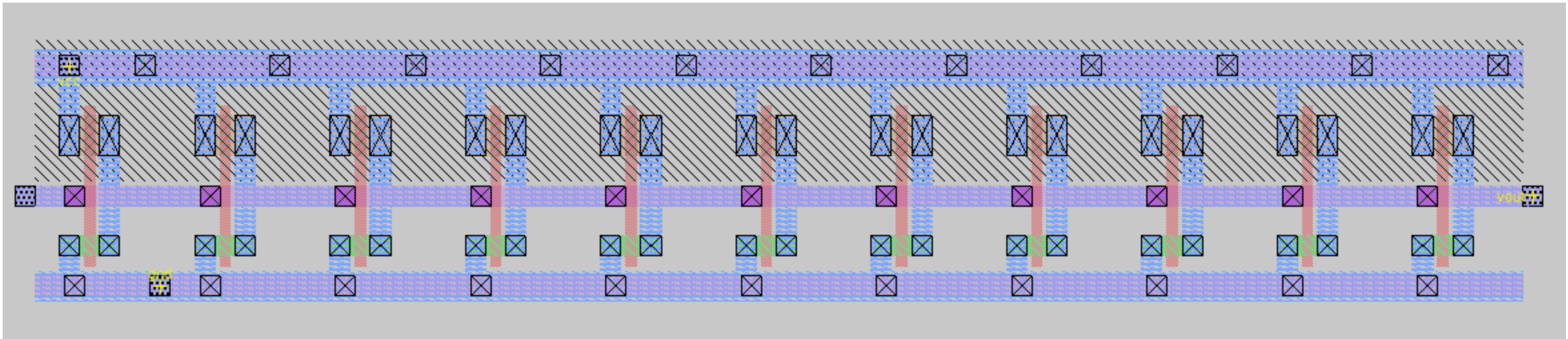
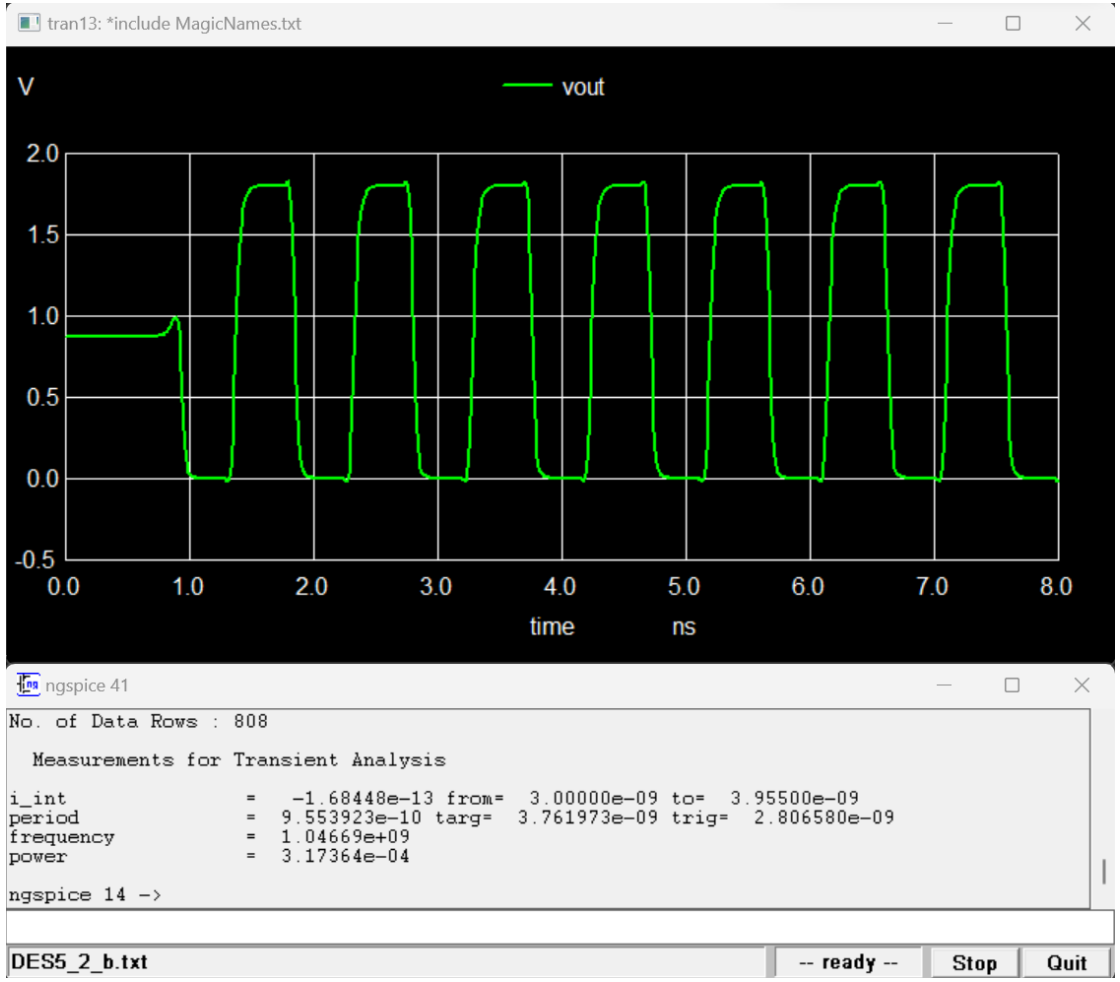
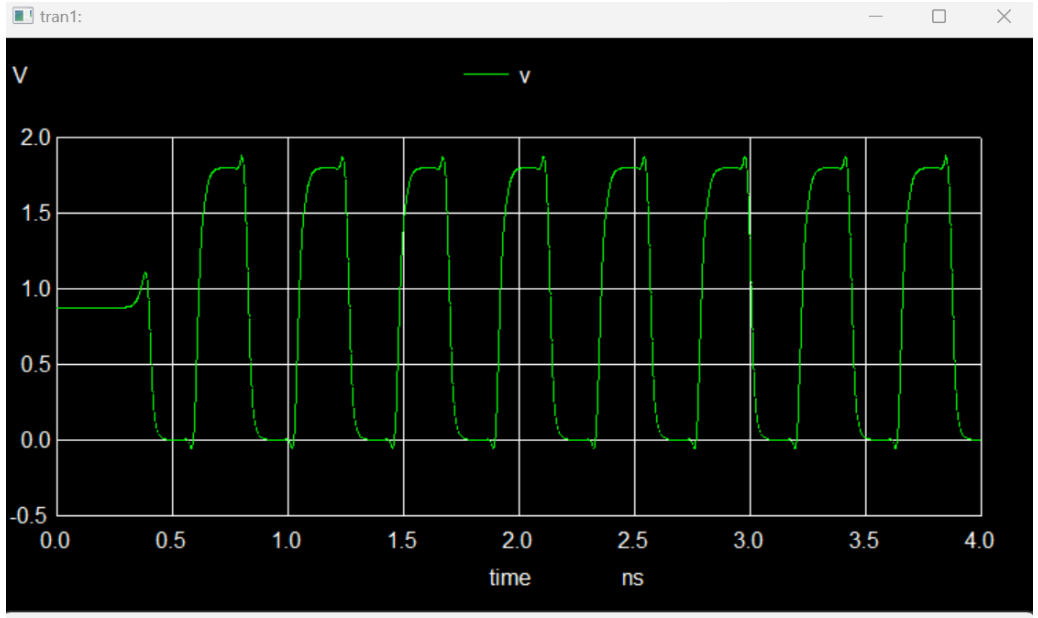
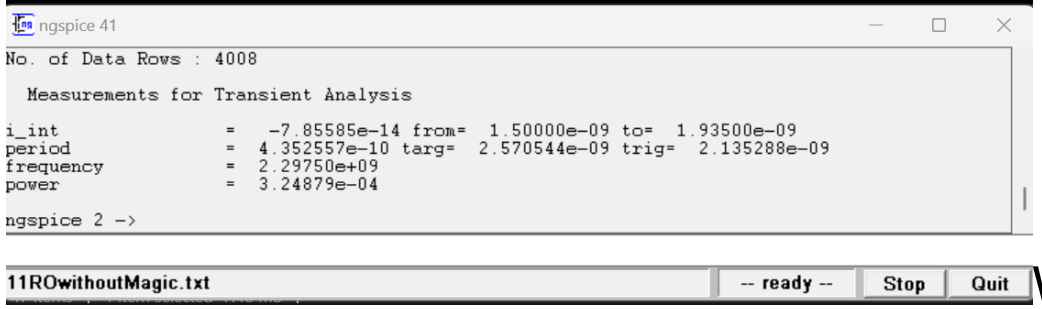

vcc
vout
gnd

3. 5xx (extra credit for 4xx): compare the frequency of oscillation of this RO circuit with and without MAGIC (1 point)



Freq with Magic = 1.0466e+9





Without Magic: freq = 2.29e+9

Frequency without magic is higher

4. 5xx extra credit (not for 4xx): compare average power for this RO with and without MAGIC (1 point)

   Power with Magic : 3.173 e-04 W
   Power without Magic : 3.248 e-04 W

   Power without magic is slightly higher