LAB-1 Basic Circuit Components

Inverter Example (Transient analysis with loading c=0.02p)

Edit Inverter SPICE, observe waveform, measure Delay time and Power consumption.

MOS transistor:

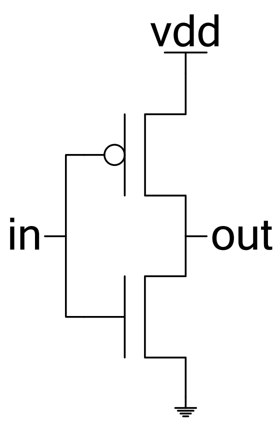
MP0	Drain	Gate	Source	Body	Mode-lname	Length	Width	*Multi-finger
MP0	outb	in	vdd	vdd	**pch**	L=0.1u	W=0.5u	*M=2

(finger number: parallel-folded number)

Sizing: Taking inverter as example. We expect the circuit can perform with the same rising time and falling. Since the current driving capability of the PMOS is inferior to that of the NMOS (PMOS is inherently slower than NMOS), the width (W) ratio of the PMOS to the NMOS is usually 2:1. If the circuits are connected in series, the conducting path will become longer. In this case, the width size of the transistor should be increased according to the serial connected number. The width of the two serial connected transistor will be W*2, the width of the three serial connected transistor will be W*3, and so on.

Example: (inverter)

```
.subckt   inv   in   out
mp0 out  in   vdd  vdd  pch  l=0.1u   w=1u
mn0 out  in   0    0    nch  l=0.1u   w=0.5u
.ends
```

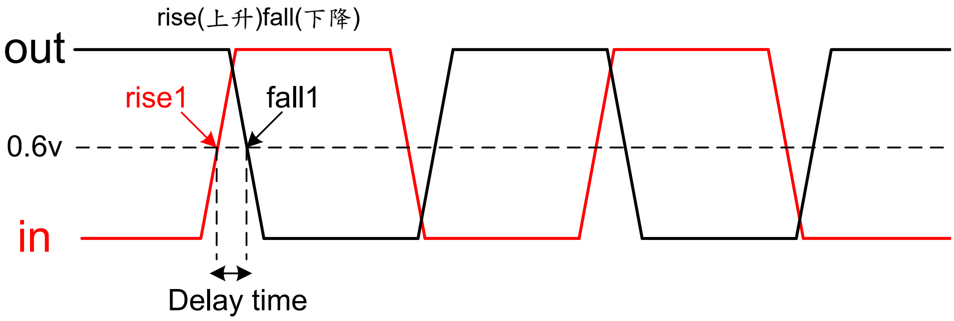


u: micro-meter.

*The following five points are the instructions you need for this experiment.

(1)Delay time Instruction: (rise represents for rising edge of signal, fall represents for falling edge of signal)

.meas tran delay trig v(in) val=0.6 rise=1 targ v(out) val=0.6 fall=1



meas: measure, tran: transient analysis, trig: trigger, targ: target, val: value.

(2)Power consumption Instruction:

.meas tran power avg power

(3)Power-Delay-Product instruction:

.meas tran pdp=param('power*delay')

(4)Instruction to sweep MOS size:

```
.tran 0.1n    50n    sweep   w1  2u  25u   1u
```

w1 is the parameter which need to be swept.

Initial value: 2u, final value: 25u, step: 1u.

Sweep from 2u, 3u, 4u, 5u, 6u, 7u,.................24u, 25u.

Example: (PMOS:NMOS=5:1，sweep size=0.5u, 1u, 1.5u, 2u)

```
m1  out  in  vdd    vdd  pch    l=0.1u   w='5*w1'
m2  out  in  0      0    nch    l=0.1u   w=w1
.tran 0.1n    50n    sweep   w1  0.5u  2u   0.5u
```

(5)Input signal pattern instruction:

```
va   a    0   pulse(1.2 0   0.1n   0.1n   0.1n   4.9n    10n)
vb   b    0   pulse(1.2 0   0.1n   0.1n   0.1n   9.9n    20n)
vc   c    0   pulse(1.2 0   0.1n   0.1n   0.1n   19.9n   40n)
vd   d    0   pulse(1.2 0   0.1n   0.1n   0.1n   39.9n   80n)
.tran  0.1n   80n
```

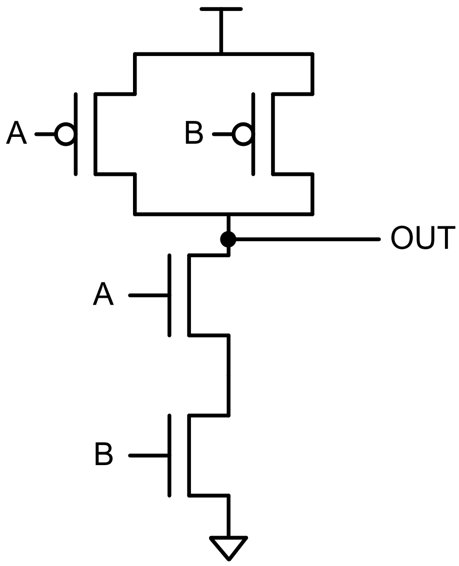
2-input NAND (Transient Analysis with loading c=0.02p)

By following the steps in inverter LAB, try to edit the circuit of 2-input NAND in SPICE. Observe waveform, measure Delay time, Power consumption and Power-Delay-Product.

1. Size: PMOS W/L=2u/0.1u, NMOS W/L=2u/0.1u (record the experimental data)

2-input NAND Example:

```
.subckt  nand    a  b  out
mp0 out  a    vdd  vdd  pch  l=0.1u    w=2u
mp1 out  b    vdd  vdd  pch  l=0.1u    w=2u
mn0 out  a    net  0    nch  l=0.1u    w=2u
mn1 net  b    0    0    nch  l=0.1u    w=2u
.ends
```

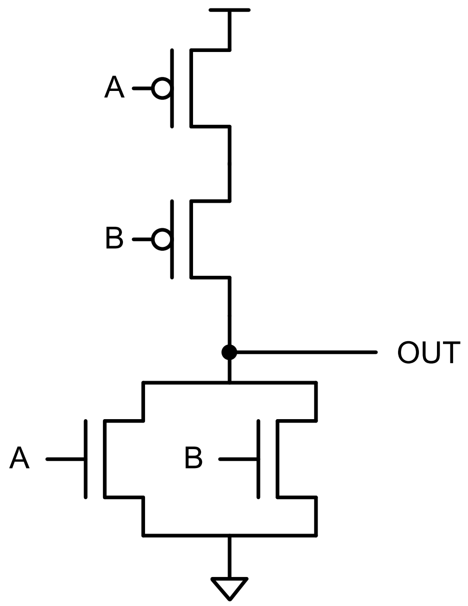


2-input NOR ***(Transient Analysis with loading c=0.02p)***

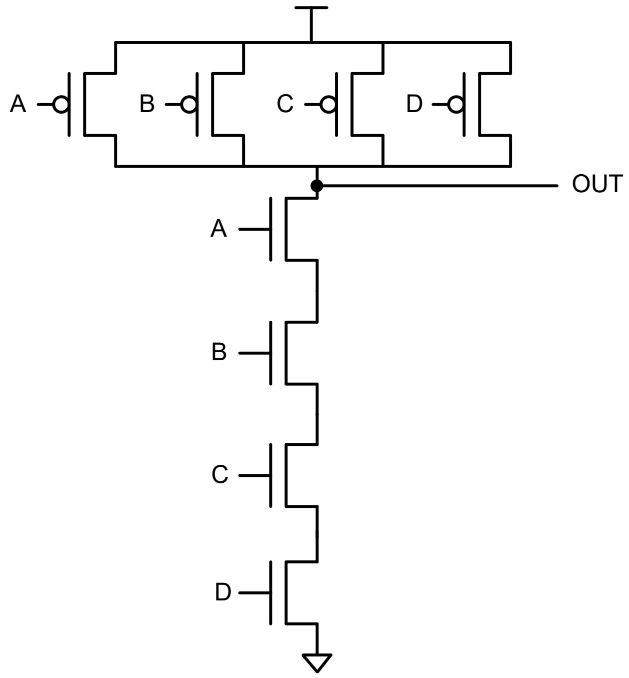
By following the steps in inverter LAB, try to edit the circuit of 2-input NAND in SPICE. Observe waveform, measure Delay time, Power consumption and Power-Delay-Product.

1. Size: PMOS W/L=4u/0.1u, NMOS W/L=1u/0.1u (record the experimental data)

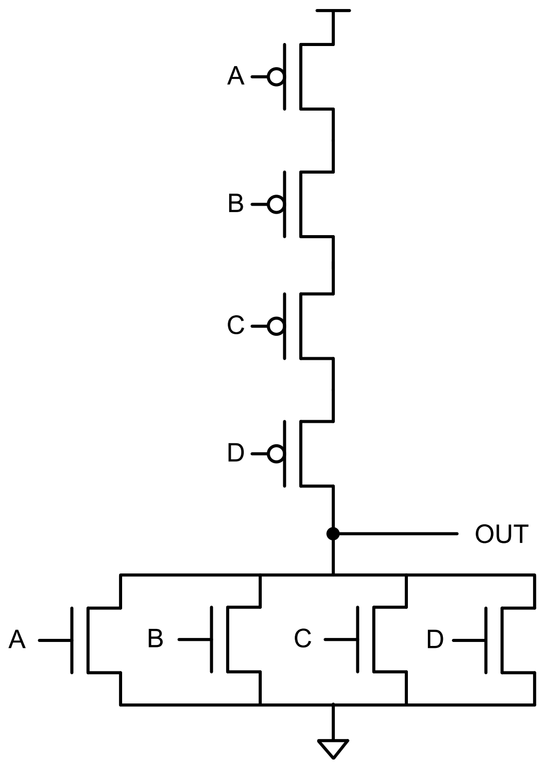
2-input NOR：



4-input NAND (Transient Analysis with loading c=0.02p)



4-input NOR (Transient Analysis with loading c=0.02p)



2-input XOR (Transient Analysis with loading c=0.02p)