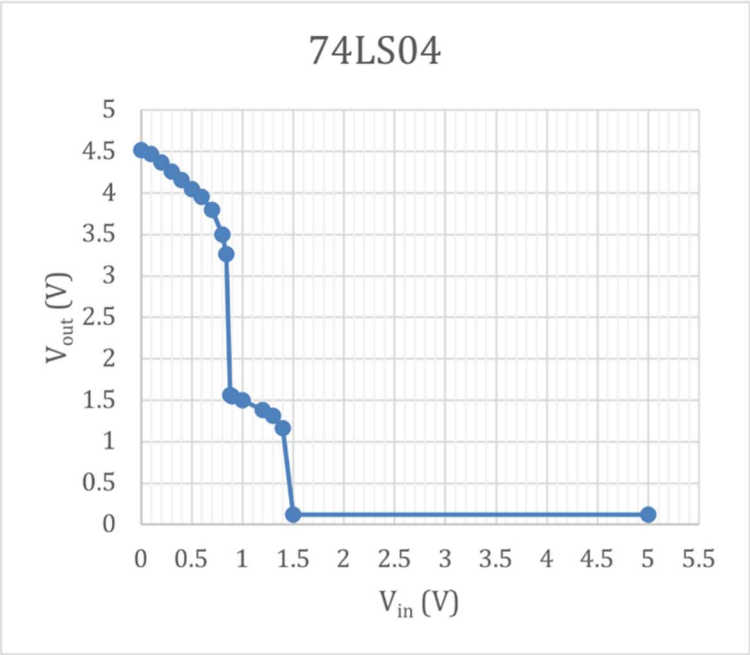
Problem Set 2: Combinational Logic

Problem Set due May 6, 2023 10:37 PDT Completed

Consider the following voltage transfer characteristic measured from a 74LS04 inverter chip operating at V_{DD} = 5 V.



VIL

1/1 point (graded)

What is V_{IL} for the circuit above? (It is hard to precisely read the graph, so a reasonable range will be accepted).

0.7 ✔

0.7

Submit Try again (1 attempt remaining) Show answer

VIH

1/1 point (graded)

What is V_{IH} for the circuit above? There are multiple unity-gain points; pick the one that maximizes noise margins. (It is hard to precisely read the graph, so a reasonable range will be accepted).

1.5 ✔

1.5

Submit Try again (1 attempt remaining) Show answer

VOL

1/1 point (graded)

What is V_{OL} for the circuit above? (It is hard to precisely read the graph, so a reasonable range will be accepted).

0.1 ✔

0.1

Submit Try again (1 attempt remaining) Show answer

VOH

1/1 point (graded)

What is V_{OH} for the circuit above? (It is hard to precisely read the graph, so a reasonable range will be accepted).

4.5 ✔

4.5

Submit Try again (1 attempt remaining) Show answer

Logic family compatibility

1/1 point (graded)

A 74HC08 AND gate has V_{IL} = 1.35, V_{IH} = 3.15, V_{OL} = 0.33, V_{OH} = 3.84. Can the 74LS04 output with the levels observed above drive a 74HC08 input?

- ○ NO, because the V_{OH} of the NOT is less than V_{IH} of the AND
- ○ NO, because the V_{OL} of the NOT is less than V_{IL} of the AND
- ○ NO, because the V_{IL} of the NOT is greater than the V_{OL} of the AND
- ○ NO, because the V_{OH} of the NOT is less than the V_{OH} of the AND
- ○ NO, because the LS and HC chips are different logic families.
- ◉ YES ✔

Submit Try again (1 attempt remaining) Show answer

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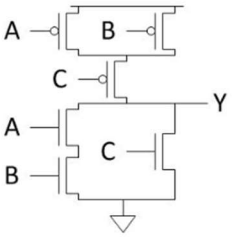
Consider the transistor-level logic gate shown below:



Transistor-Level Gate Analysis

1/1 point (graded)

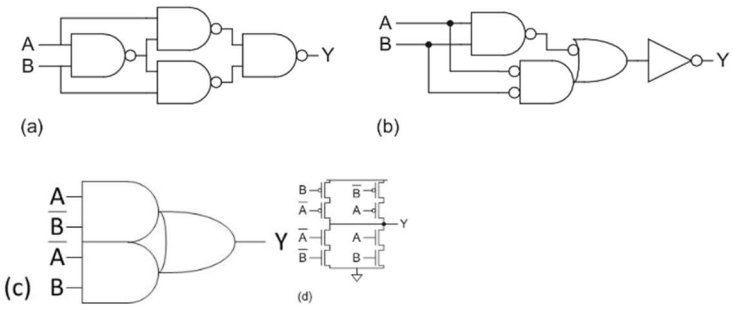
What logic function does the circuit above perform?

- (●) Y = ~(AB + C)
- ( ) Y = AB + C
- ( ) Y = ~((A+B)C)
- ( ) Y = (A+B)C
- ( ) Y = ~(AB)

✔

Submit Try again (1 attempt remaining) Show answer

Consider the circuits below.



XOR designs

1/1 point (graded)

Which of the circuits above performs Y = A XOR B? Select all that apply.

- [x] (a)
- [x] (b)
- [x] (c)
- [x] (d)
- [ ] none of the above

✔

Submit | Try again (1 attempt remaining) | Show answer

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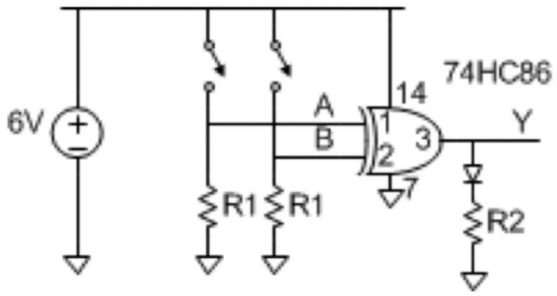
It will be helpful to watch the Datasheets video in the Lab Practices section or read Section A.5 of the textbook to learn to interpret the data sheet.

The following circuit turns on an LED when you press one button or another but not both. The circuit operates directly from a 6V Ni-MH battery with a 280 mA-hr energy capacity. (This means the battery could deliver 280 mA for 1 hour, 1 mA for 280 hours, or any other combination of current and time whose product is 280). See the 74HC86 data sheet for chip details. The circuit is in a hot enclosure at 85 °C. You push the buttons slowly enough that dynamic power consumption is negligible. Use worst-case values to ensure that the system is guaranteed to meet the specs.



As you are doing this problem, keep in mind Ohm's Law that voltage = current * resistance. Also remember that Power = voltage * current.

Quiescent Power Consumption

1/1 point (graded)

What is the quiescent power consumption of the XOR gate in the hot enclosure. (This is the static power drawn from the power supply pin.) Give your answer in microwatts.

120 ✔

120

Submit Try again (1 attempt remaining) Show answer

Pulldown Resistor Selection

1/1 point (graded)

According to the datasheet, a small amount of leakage current flows through the input pins. This leakage causes a voltage drop across R1. What value of R1 should you select to minimize power consumption when the button is pressed, while still guaranteeing a valid logic level at the input of the XOR when the button is not pressed. Give your answer on ohms.

1.8e6 ✔

1.8×10^6

Submit Try again (1 attempt remaining) Show answer

Current Limiting Resistor Selection

1/1 point (graded)

Assume the voltage drop across the LED is 2 V when it is ON. According to the datasheet, there is a maximum output current specification for which the XOR is guaranteed to produce a valid output logic level at the given operating voltage. Choose R2 so that the LED is as bright as possible without exceeding this current specification. For worst case analysis, assume the output is at VCC, not VOH, when calculating the voltage across the resistor. Express your value of R2 in ohms.

769 ✔

769

Submit You have used 2 of 2 attempts Show answer

Average Power Consumption

1/1 point (graded)

Suppose that both buttons are pressed 99.9% of the time, and that a single button is pressed the remainder of the time. What is the average power consumption? Be sure to account for quiescent power consumption of the chip, power dissipated in the input resistors, and power delivered to the load. Assume the output is at either VCC or GND. Express your answer in microwatts.

200 ✔

200

Battery Life

1/1 point (graded)

Given the average power consumption, how long will the battery last? Express your answer in weeks.

49 ✔

49

Submit Try again (1 attempt remaining) Show answer

Brighter LED

1/1 point (graded)

Suppose you didn't care about whether the output logic level is valid and were willing to violate the I_{OH} spec to make the LED brighter. What is the minimum value of R2 that you could use without risking damage to the 74HC86? Conservatively assume the output voltage is at VCC even with this small resistance. Express your answer in ohms.

160 ✔

160

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Multiple Choice

1/1 point (graded)

Simplify Y = ~(ABC) + A(~B) to minimal sum of products form.

- (●) ~A + ~B + ~C
- ( ) A(~B)
- ( ) A(~B) + (~B)~C
- ( ) (~A)(~B)(~C) + A(~B)

✔

Submit Try again (1 attempt remaining) Show answer

Consider the following truth table.

A	*B*	*C*	*D*	*Y*
0	0	0	0	0
0	0	0	1	1
0	0	1	0	X
0	0	1	1	X
0	1	0	0	0
0	1	0	1	X
0	1	1	0	X
0	1	1	1	X
1	0	0	0	1
1	0	0	1	0
1	0	1	0	0
1	0	1	1	1
1	1	0	0	0
1	1	0	1	1
1	1	1	0	X
1	1	1	1	1

Multiple Choice

1/1 point (graded)

What is the minimal sum of products equation for the truth table above, taking advantage of don't cares?

- A(~B)(~C)(~D) + D
- **A(~B)(~C)(~D) + (~A)D + BD + CD** ✔
- A(~B)(~C)(~D) + (~A)D + BD + CD + (~A)C + BC
- A(~B)(~C)(~D) + (~A)(~B)(~C)D + ABD + ACD

Submit | Try again (1 attempt remaining) | Show answer