Laboratory Assignment 4: Design of Combination Logic Circuits

ECE 0201: Digital Circuits and Systems

45 Points

Name

张鹤扬 Stefan

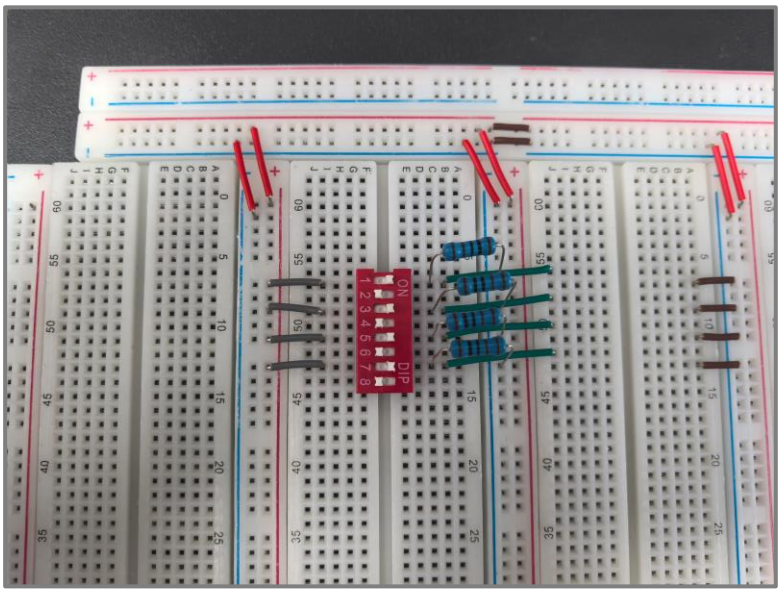
Submission Checklist:

- ☐ Write within boxes, do not move boxes
- ☐ Write your full name in the box above
- ☐ Save this file as a PDF before uploading, keep the number of pages (**14**) unchanged
- ☐ Note “TO BE CONTINUED” in the answer box if you used the extra pages (12-14)

Part I: Logic Sources using DIP switches (7 points)

Four Logic Sources – Dip Switch and Four 1000 Ohm Resistors

[(A) Insert a picture of your build of the circuit] (1 point)



[(B) Measure voltage of each of the logic sources when its corresponding switch is open or closed. Briefly explain the logic levels produced in each of the two switch states (open or closed)] (2 points)

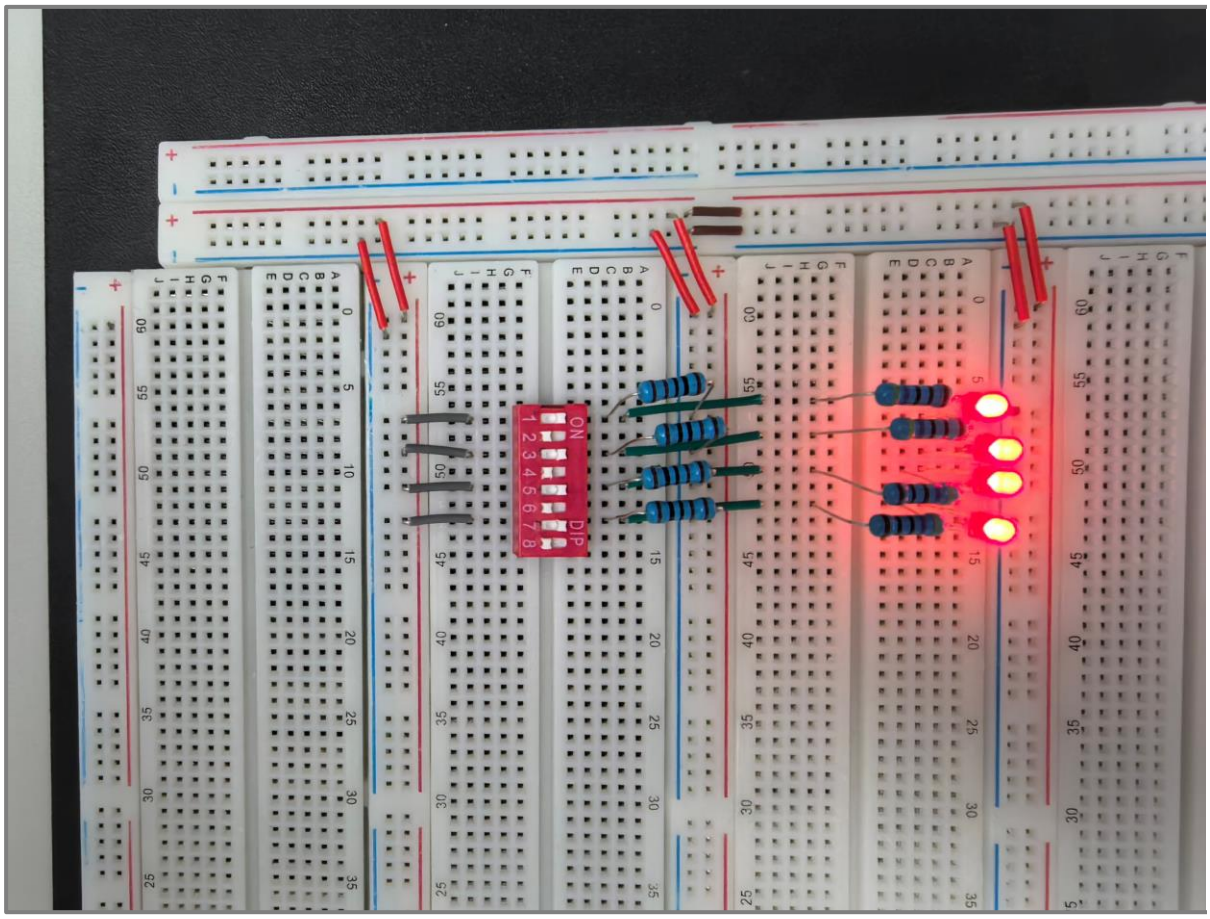
OPEN	CLOSE
0.637mV	4.9956V
0.655mV	4.9957V
0.214mV	4.9963V
0.009mV	4.9959V

When the switch is open, the state is low level with lower voltage

When the switch is closed, the state is high level with higher voltage.

Logic Source, 470 (or close to) Ohm Resistor, and LED in Series

[(A) Insert a picture of your build of the circuit in Figure 2] (1 point)



[(B) Fill out the following information] (2 points)

V_x when switch 1 is closed = 4.9917V
V_x when switch 1 is opened = 0.908mV
LED 1 state (on/off) when switch 1 is open = OFF
LED 1 state (on/off) when switch 1 is closed = ON

V_x when switch 2 is closed = 4.9920V
V_x when switch 2 is opened = 0.923mV
LED 2 state (on/off) when switch 2 is open = OFF
LED 2 state (on/off) when switch 2 is closed = ON

V_x when switch 3 is closed = 4.9920V
V_x when switch 3 is opened = 0.927mV
LED 3 state (on/off) when switch 3 is open = OFF
LED 3 state (on/off) when switch 3 is closed = ON

V_x when switch 4 is closed = 4.9901V
V_x when switch 4 is opened = 0.932mV
LED 4 state (on/off) when switch 4 is open = OFF
LED 4 state (on/off) when switch 4 is closed = ON

[(C) Briefly explain why the logic levels produced are valid/invalid in each of the two switch states (open or closed)] (1 point)

The logic levels are valid because they fall within the acceptable voltage thresholds for TTL logic.

When the switch is open, the input voltage is near 0 V, which is below 1.5 V and therefore recognized as a valid logic low (0).

When the switch is closed, the input voltage is near 5 V, which is above 3.5 V and therefore recognized as a valid logic high (1).

Part II: Two-Bit Multiplier Logic Design (12 points)

Truth Table

[(A) Fill out the following truth table for a 2-bit Multiplier as shown in Table 1] (2 points)

A1	A0	B1	B0	P3	P2	P1	P0
0	0	0	0	0	0	0	0
0	0	0	1	0	0	0	0
0	0	1	0	0	0	0	0
0	0	1	1	0	0	0	0
0	1	0	0	0	0	0	0
0	1	0	1	0	0	0	1
0	1	1	0	0	0	1	0
0	1	1	1	0	0	1	1
1	0	0	0	0	0	0	0
1	0	0	1	0	0	1	0
1	0	1	0	0	1	0	0
1	0	1	1	0	1	1	0
1	1	0	0	0	0	0	0
1	1	0	1	0	0	1	1
1	1	1	0	0	1	1	0
1	1	1	1	1	0	0	1

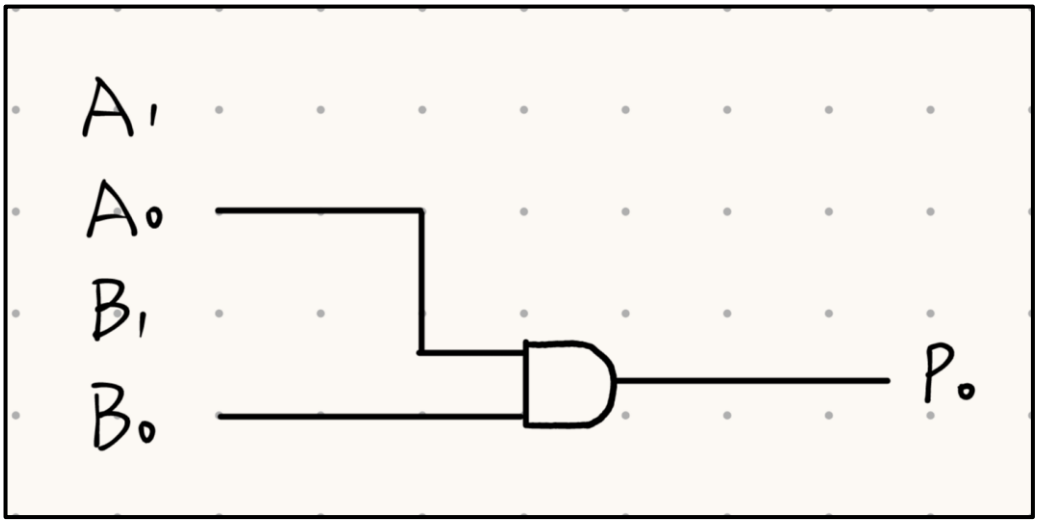
Circuit Design Schematics

[(A) Determine the logic function for P0 and draw the schematic of your design] (1 point)

Logic function:

$$P_0 = A_0 B_0$$

Schematic



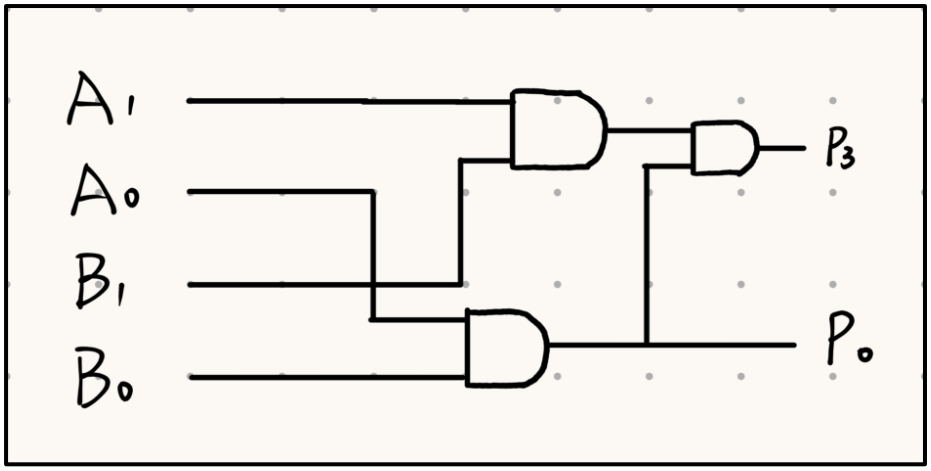
[(B) Determine the logic function of P0 and P3 and draw the schematic of a circuit that produces both] (2 points)

Logic function:

$$P_0 = A_0 B_0$$

$$P_3 = A_0 A_1 B_0 B_1$$

Schematic:



[(C) Determine the logic function of P0, P2, and P3 and draw the schematic of a circuit that produces all three] (3 points)

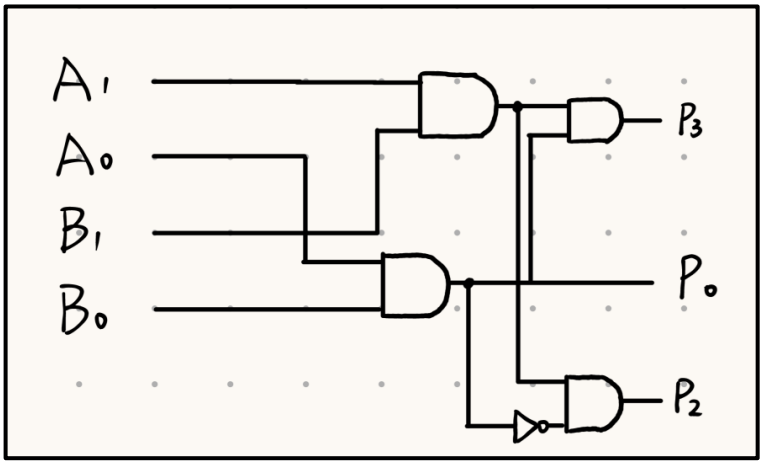
Logic function:

$$P_0 = A_0 B_0$$

$$P_2 = A_1 B_1 (A_0 B_0)'$$

$$P_3 = A_1 A_0 B_1 B_0$$

Schematic:

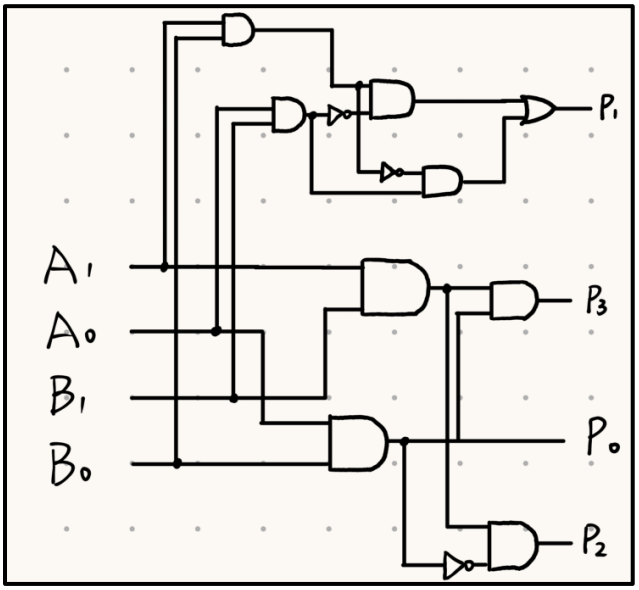


Complete Two-Bit Multiplier

[(A) Determine the logic function of P0, P1, P2, and P3. Draw the schematic of your design of a complete two-bit multiplier] (4 points)

Logic function: $P_0 = A_0B_0; P_1 = (A_1B_0) \oplus (A_0B_1); P_2 = A_1B_1(A_0B_0)'; P_3 = A_1A_0B_1B_0$

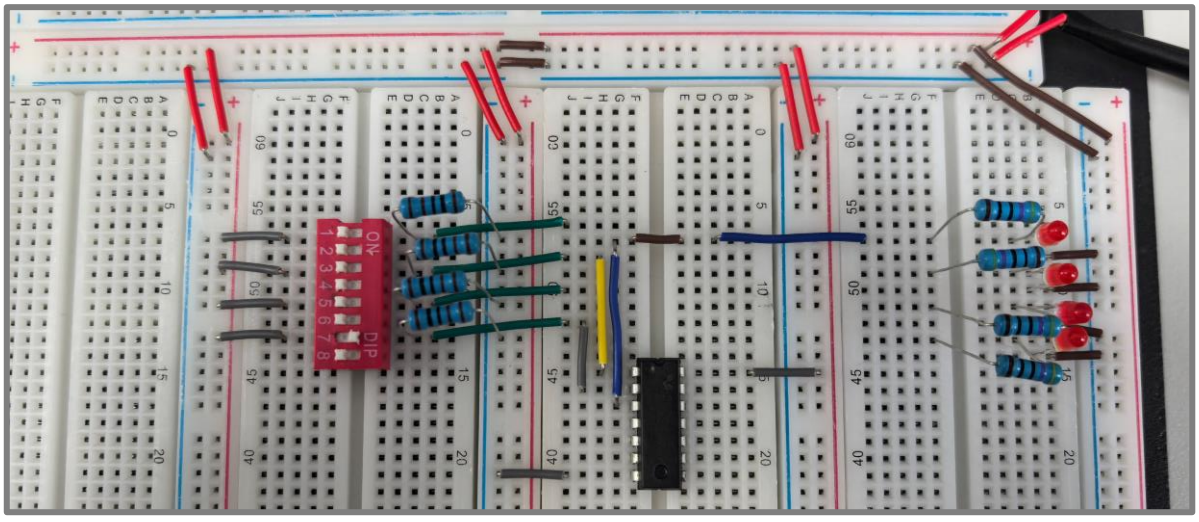
Schematic:



Part III: Two-Bit Multiplier Implementation (26 points)

Circuit with Output P0

[(A) Insert a picture of your build of the circuit you designed to produce P0] (1 point)

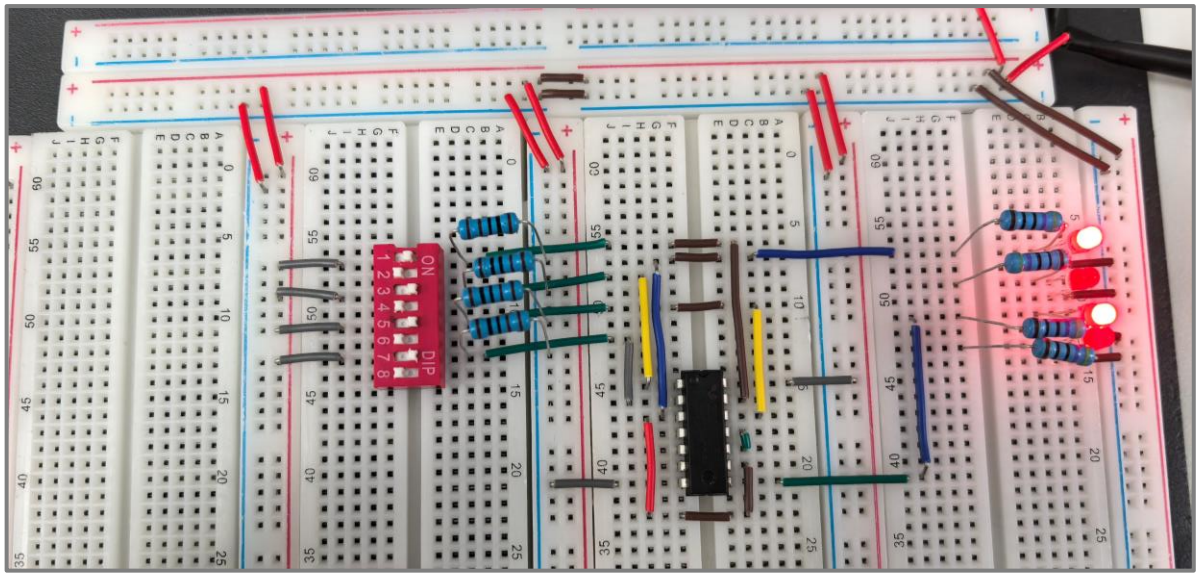


[(B) Fill out the following information] (2 points)

S1	S2	S3	S4	LED P0 (on/off)
Open	Open	Open	Open	OFF
Open	Open	Open	Closed	OFF
Open	Open	Closed	Open	OFF
Open	Open	Closed	Closed	OFF
Open	Closed	Open	Open	OFF
Open	Closed	Open	Closed	ON
Open	Closed	Closed	Open	OFF
Open	Closed	Closed	Closed	ON
Closed	Open	Open	Open	OFF
Closed	Open	Open	Closed	OFF
Closed	Open	Closed	Open	OFF
Closed	Open	Closed	Closed	OFF
Closed	Closed	Open	Open	OFF
Closed	Closed	Open	Closed	ON
Closed	Closed	Closed	Open	OFF
Closed	Closed	Closed	Closed	ON

Circuit with Outputs P0 and P3

[(A) Insert a picture of your build of the circuit you designed to produce P0 and P3] (1 point)

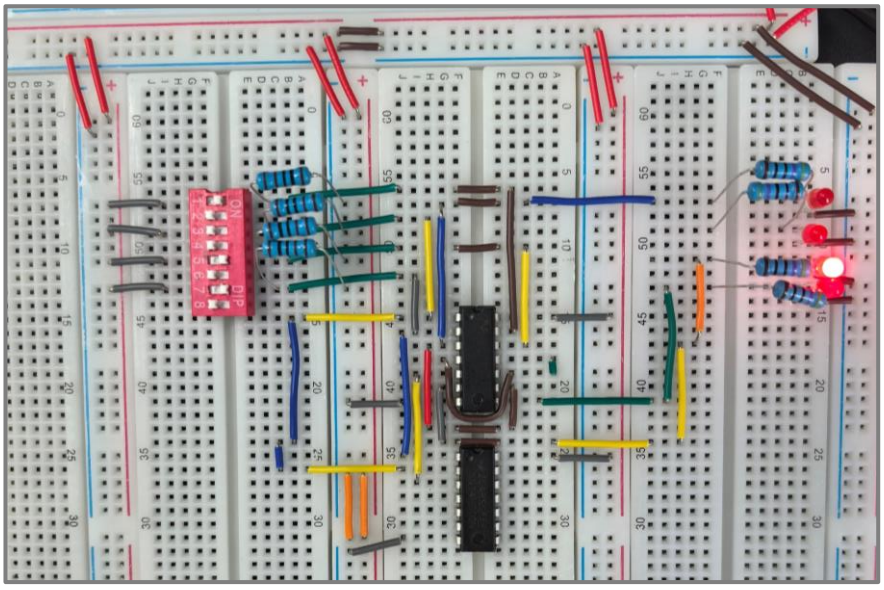


[(B) Fill out the following information] (2 points)

S1	S2	S3	S4	LED P3 (on/off)	LED P0 (on/off)
Open	Open	Open	Open	OFF	OFF
Open	Open	Open	Closed	OFF	OFF
Open	Open	Closed	Open	OFF	OFF
Open	Open	Closed	Closed	OFF	OFF
Open	Closed	Open	Open	OFF	OFF
Open	Closed	Open	Closed	OFF	ON
Open	Closed	Closed	Open	OFF	OFF
Open	Closed	Closed	Closed	OFF	ON
Closed	Open	Open	Open	OFF	OFF
Closed	Open	Open	Closed	OFF	OFF
Closed	Open	Closed	Open	OFF	OFF
Closed	Open	Closed	Closed	OFF	OFF
Closed	Closed	Open	Open	OFF	OFF
Closed	Closed	Open	Closed	OFF	ON
Closed	Closed	Closed	Open	OFF	OFF
Closed	Closed	Closed	Closed	ON	ON

Circuit with Outputs P0, P2, and P3

[(A) Insert a picture of your build of the circuit you designed to produce P0, P2, and P3] (1 point)

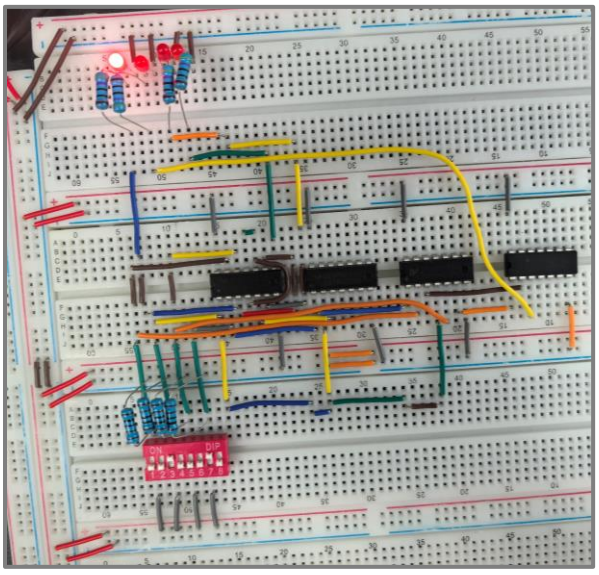


[(B) Fill out the following information] (2 points)

S1	S2	S3	S4	LED P3 (on/off)	LED P2 (on/off)	LED P0 (on/off)
Open	Open	Open	Open	OFF	OFF	OFF
Open	Open	Open	Closed	OFF	OFF	OFF
Open	Open	Closed	Open	OFF	OFF	OFF
Open	Open	Closed	Closed	OFF	OFF	OFF
Open	Closed	Open	Open	OFF	OFF	OFF
Open	Closed	Open	Closed	OFF	OFF	ON
Open	Closed	Closed	Open	OFF	OFF	OFF
Open	Closed	Closed	Closed	OFF	OFF	ON
Closed	Open	Open	Open	OFF	OFF	OFF
Closed	Open	Open	Closed	OFF	OFF	OFF
Closed	Open	Closed	Open	OFF	ON	OFF
Closed	Open	Closed	Closed	OFF	ON	OFF
Closed	Closed	Open	Open	OFF	OFF	OFF
Closed	Closed	Open	Closed	OFF	OFF	ON
Closed	Closed	Closed	Open	OFF	ON	OFF
Closed	Closed	Closed	Closed	ON	OFF	ON

Complete Circuit (P0, P1, P2, P3)

[(A) Insert a picture of your build of the circuit you designed to produce P0, P2, and P3] (1 point)



[(B) Fill out the following information] (2 points)

S1	S2	S3	S4	LED P3 (on/off)	LED P2 (on/off)	LED P1 (on/off)	LED P0 (on/off)
Open	Open	Open	Open	OFF	OFF	OFF	OFF
Open	Open	Open	Closed	OFF	OFF	OFF	OFF
Open	Open	Closed	Open	OFF	OFF	OFF	OFF
Open	Open	Closed	Closed	OFF	OFF	OFF	OFF
Open	Closed	Open	Open	OFF	OFF	OFF	OFF
Open	Closed	Open	Closed	OFF	OFF	OFF	ON
Open	Closed	Closed	Open	OFF	OFF	ON	OFF
Open	Closed	Closed	Closed	OFF	OFF	ON	ON
Closed	Open	Open	Open	OFF	OFF	OFF	OFF
Closed	Open	Open	Closed	OFF	OFF	ON	OFF
Closed	Open	Closed	Open	OFF	ON	OFF	OFF
Closed	Open	Closed	Closed	OFF	ON	ON	OFF
Closed	Closed	Open	Open	OFF	OFF	OFF	OFF
Closed	Closed	Open	Closed	OFF	OFF	ON	ON
Closed	Closed	Closed	Open	OFF	ON	ON	OFF
Closed	Closed	Closed	Closed	ON	OFF	OFF	ON

[(C) Demonstrate constructed complete circuit to TA for check-off] (14 points)

EXTRA PAGES

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