

Digital Design hwk 2

Sunday, October 13, 2019 12:22 PM

2.24 For the function $F = a'd' + a'c + b'cd' + cd$:

- List all the variables.
- List all the literals.
- List all the product terms.

- (a) a, b, c, d
- (b) $a', d', a', c, b', c, d', c, d$
- (c) $a'd', a'c, b'cd', cd$

2.26 Let variables S represent a package being small, H being heavy, and E being expensive. Let's consider a package that is not small as big, not heavy as light, and not expensive as inexpensive. Write a Boolean equation to represent each of the following:

- Your company specializes in delivering packages that are both small and inexpensive (a package must be small AND inexpensive for us to deliver it); you'll also deliver packages that are big but only if they are expensive.
- A particular truck can be loaded with packages only if the packages are small and light, small and heavy, or big and light. Simplify the equation.
- Your above-mentioned company buys the above-mentioned truck. Write an equation that describes the packages your company can deliver. Hint: Appropriately combine the equations from the above two parts.

$$S = \text{small} \quad H = \text{heavy} \quad E = \text{expensive}$$

- (a) $SE' + S'E$
- (b) $SH' + SH + S'H'$
- (c) $(SE' + S'E)(SH' + SH + S'H') = SSE'H' + SSE'H + SS'E'H' + S'SE'H + S'SEH + S'S'E'H'$

2.29 Use DeMorgan's Law to find the inverse of the following equation: $F = abc + a'b$.

Reduce to sum-of-products form. Hint: Start with $F' = (abc + a'b)'$

$$\begin{aligned} F' &= (abc + a'b)' \\ &= (abc)'(a'b)' \\ &= (a' + b' + c')(a'' + b') \\ &= (a' + b' + c')(a + b') \\ &= a(a' + b' + c') + b'(a' + b' + c') \\ &= 0 + ab' + ac' + a'b' + b' + b'c' \\ &\cancel{= (a+a')b' + b' + ac' + b'c'} \\ &= b' + ac' \end{aligned}$$

2.32 Create a Boolean equation representation of the digital circuit in Figure 2.78.

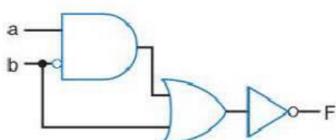


Figure 2.78 Combinational circuit for F .

$$F = (ab' + b)$$

TABLE 2.10 Truth table.

a	b	c	F
0	0	0	1
0	0	1	0
0	1	0	1
0	1	1	0
1	0	0	1
1	0	1	1
1	1	0	1
1	1	1	0

Figure 2.78 Combinational circuit for F.

1	0	0	1
1	0	1	1
1	1	0	1
1	1	1	0

2.39 Convert the function F shown in the truth table in Table 2.10 to an equation. Don't minimize the equation.

$$F = a'b'c' + abc' + a'bc' + ab'c' + a'b'c' + ab'c + abc' + a'b'c'$$

40 Use algebraic manipulation to minimize the equation obtained in Exercise 2.39.

$$\begin{aligned} F &= a'b'c' + a'b'c' + ab'c' + ab'c + abc' \\ &= a'(b'c' + bc') + a(b'c' + b'c + bc') \\ &= a'((b'+b)c') + a(b'(c'+c) + bc') \\ &= a'c' + a(b' + bc') \end{aligned}$$

2.44 Create a truth table for the circuit of Figure 2.79.

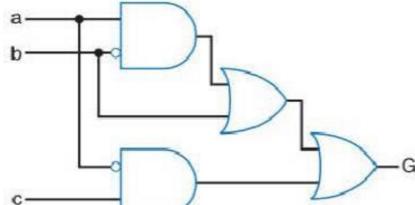


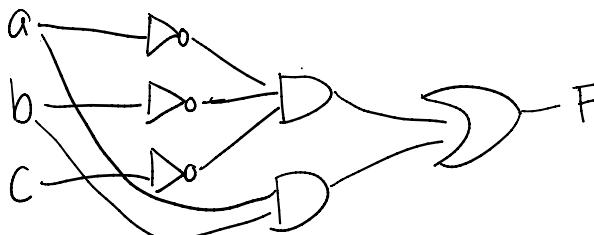
Figure 2.79 Combinational circuit for G.

a	b	c	$ab' + b$	$a'c$	F
0	0	0	0	0	0
0	0	1	0	1	1
0	1	0	1	0	1
0	1	1	1	0	1
1	0	0	1	1	1
1	1	0	1	0	1
1	0	1	1	0	1
1	1	1	1	0	1

TABLE 2.11 Truth table.

a	b	c	F
0	0	0	0
0	0	1	1
0	1	0	0
0	1	1	0
1	0	0	0
1	0	1	0
1	1	0	1
1	1	1	1

2.47 Convert the function F shown in the truth table in Table 2.11 to a digital circuit.



2.48 Convert the following Boolean equations to canonical sum-of-minterms form:

$$(a) F(a,b,c) = a'bc + ab$$

$$(b) F(a,b,c) = a'b$$

$$(c) F(a,b,c) = abc + ab + a + b + c$$

$$(d) F(a,b,c) = c'$$

$$\begin{aligned} @) F &= a'bc + ab \\ &= a'bc + ab(c+c') \\ &= a'bc + abc + abc' \end{aligned}$$

$$\textcircled{b}) F = a'b \\ = a'b(c+c')$$

$$\begin{aligned} \textcircled{c}) F &= abc + ab + a + b + c \\ &= abc + ab(c+c') + a(b+b')(c+c') \\ &\quad + b(a+a')(c+c') \\ &\quad + c(a+a')(b+b') \\ &= abc + abc + abc' + abc + abc' \\ &\quad + ab'c + ab'c' + abc + abc' + a'b'c' + a'b'c \end{aligned}$$

$$\begin{aligned}
 \text{(b)} \quad F &= a'b \\
 &= a'b(c+c') \\
 &= a'bc + a'b c'
 \end{aligned}$$

$$\begin{aligned}
 \text{(d)} \quad F &= c' \\
 &= c'(a+a')(b+b') \\
 &= abc' + a'bc' + ab'c' + a'b'c'
 \end{aligned}$$

$$\begin{aligned}
 &= abc + abc + abc' + abc + abc' \\
 &\quad + ab'c + ab'c' + abc + abc' + a'bc \\
 &\quad + a'bc' + abc + a'bc + ab'c + a'b'c \\
 &= abc + abc' + ab'c + ab'c' + a'bc \\
 &\quad + a'b'c' + a'b'c
 \end{aligned}$$

2.52 Determine whether the two circuits in Figure 2.81 are equivalent circuits, using (a) algebraic manipulation and (b) truth tables.

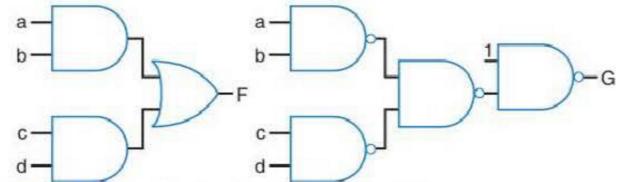


Figure 2.81 Combinational circuits for F and G.

$$\textcircled{a} \quad F = ab + cd$$

$$G = ((ab)^1(cd)^1)^1$$

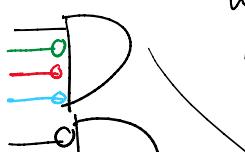
Not equivalent,
by doing part b
I see that the
outputs are the inverse
of each other

a	b	c	d	F	a	b	c	d	G
0	0	0	0	0	0	0	0	0	1
0	0	0	1	0	0	0	0	1	1
0	0	1	0	0	0	0	1	0	1
0	0	1	1	1	0	0	1	1	0
0	1	0	0	0	0	1	0	0	1
0	1	0	1	0	0	1	0	1	1
0	1	1	0	0	0	1	1	0	1
0	1	1	1	1	0	1	1	1	0
1	0	0	0	0	1	0	0	0	1
1	0	0	1	0	1	0	0	1	1
1	0	1	0	0	1	0	1	0	1
1	0	1	1	1	1	0	1	1	0
1	1	0	0	1	1	1	0	0	0
1	1	0	1	1	1	1	0	1	0
1	1	1	0	1	1	1	1	0	0
1	1	1	1	1	1	1	1	1	0

output.

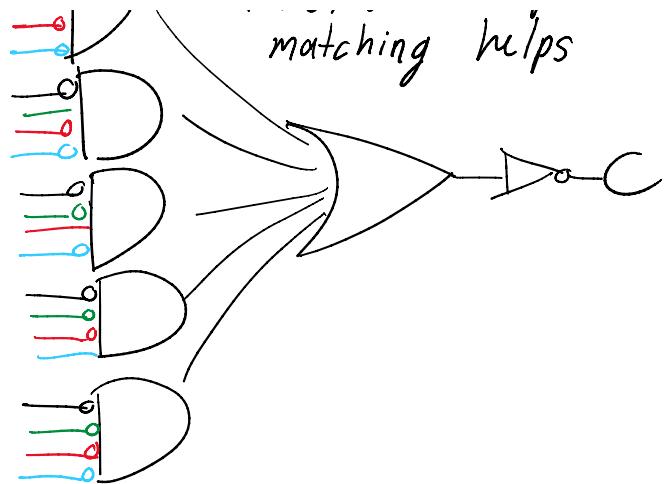
2.57 A network router connects multiple computers together and allows them to send messages to each other. If two or more computers send messages simultaneously, the messages "collide" and must be re-sent. Using the combinational design process of Table 2.5, create a collision detection circuit for a router that connects 4 computers. The circuit has 4 inputs labeled M0 through M3 that are 1 when the corresponding computer is sending a message and 0 otherwise. The circuit has one output labeled C that is 1 when a collision is detected and 0 otherwise.

M0
M1



was having trouble making
lines, so I hope color
matching helps

M1
M2
M3

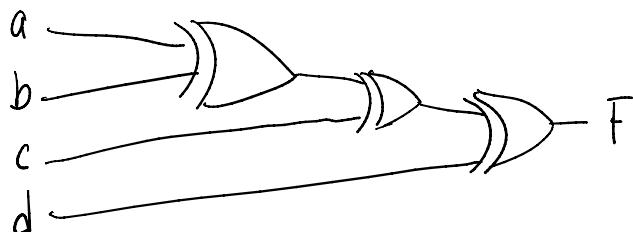


cator light (by setting an output L to 1) when the fuel level drops below level 5.

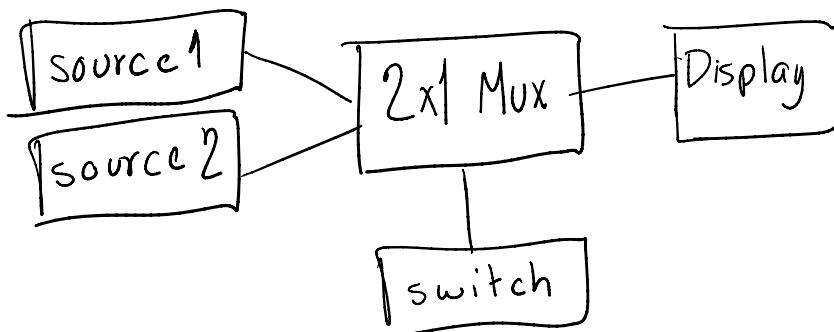
- 2.60 A car has a low-tire-pressure sensor that outputs the current tire pressure as a 5-bit binary number. Create a circuit that illuminates a “low tire pressure” indicator light (by setting an output T to 1) when the tire pressure drops below 16. Hint: you might find it easier to create a circuit that detects the inverse function. You can then just append an inverter to the output of that circuit.

$$\begin{array}{r} 00000 \\ 16 \ 8 \ 4 \ 2 \ 1 \\ P = 10000 = 16 \\ T = \text{Light} \end{array} \quad P \rightarrow \text{Do} - T$$

- 2.66 Use 2-input XOR gates to create a circuit that outputs a 1 when the number of 1s on inputs a , b , c , d is odd.



- 2.75 A video system can accept video from one of two video sources, but can only display one source at a given time. Each source outputs a stream of digitized video on its own 8-bit output. A switch with a single-bit output chooses which of the two 8-bit streams will be passed on a display's single 8-bit input. Create a circuit to connect the two video sources, the switch, and the display. Use at least one mux (a single mux or an N -bit mux) or decoder. Use block symbols, each with a clearly defined function, such as “2x1 mux,” “8-bit 2x1 mux,” or “3x8 decoder”; do not show the internal design of a mux or decoder.



SECTION 2.10: ADDITIONAL CONSIDERATIONS

- 2.77 Determine the critical path of the following specified circuits. Assume that each AND and OR gate has a delay of 1 ns, each NOT gate has a delay of 0.75 ns, and each wire has a delay of 0.5 ns.

- (a) The circuit of Figure 2.37.
(b) The circuit of Figure 2.41.

uation for p. The fully labeled circuit is shown in

(b) The circuit of Figure 2.41.

junction for F. The fully labeled circuit is shown in

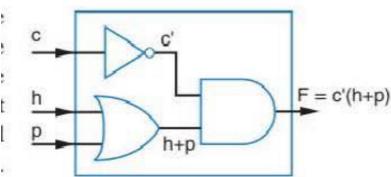
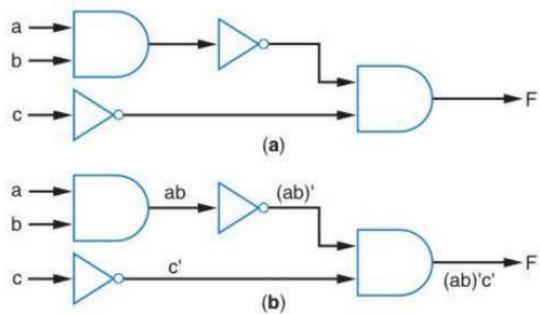


Figure 2.37 Converting a circuit to an equation.

Figure 2.41 Converting a circuit to an equation: (a) original circuit, and (b) circuit with gates' output expressions labeled.



Ⓐ $c \rightarrow F = 0.5 + 0.75 + 0.5 + 1 + 0.5 = 3.25 \text{ ns}$

$h \rightarrow F = 0.5 + 1 + 0.5 + 1 + 0.5 = 3.5 \text{ ns} \quad \nearrow \text{critical paths}$

$p \rightarrow F = 0.5 + 1 + 0.5 + 1 + 0.5 = 3.5 \text{ ns}$

Ⓑ $a \rightarrow F = 0.5 + 1 + 0.5 + 0.75 + 0.5 + 1 + 0.5 = 4.75 \text{ ns} \quad \nearrow \text{critical paths}$

$b \rightarrow F = 0.5 + 1 + 0.5 + 0.75 + 0.5 + 1 + 0.5 = 4.75 \text{ ns}$

$c \rightarrow F = 0.5 + 0.75 + 0.5 + 1 + 0.5 = 3.25 \text{ ns}$