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Final Exam

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1 Chapter 1 - Introductory Concepts

1. Suppose we have a parallel data stream of 4-bits. Each clock cyle, 4 bits are recieved. The clock period is 0.1 microseconds. How many bits per second are being transmitted?

$\frac{4 \text{ bits}}{0.1 \text{ ms}} \cdot \frac{1 \text{ ms}}{1 \times 10^{-6} \text{ s}} = \frac{4 \text{ bits}}{1 \times 10^{-7} \text{ s}}$ $1 \text{ ms} = 1 \times 10^{-6} \text{ s}$ $0.1 \text{ ms} = 1 \times 10^{-7} \text{ s}$

2. A system sends digital pulses with pulse widths of 20 ns at a frequency of 10 MHz. What is the duty cycle of these pulses?

duty cycle $= PW(secs) \cdot F(Hz) \cdot 100$ $= (2 \times 10^{-8}) \cdot (1 \times 10^{-7}) \cdot 100 =$ $20 \text{ ns} = 2 \times 10^{-8} \text{ s}$ $10 \text{ MHz} = 1 \times 10^{-7} \text{ Hz}$

3. **Special topics: ADCs** If an ADC input range goes from 0.0 to 2.5 Volts, and digitizes analog voltages into 8-bit binary numbers, what is the smallest change in voltage the system could detect?

$$\frac{2.5 \text{ V}}{2^8} = 9.7656 \times 10^{-3} \text{ V}$$

2 Chapter 2 - Number Systems and Codes

1. (a) How many bits are necessary to create binary numbers to represent each letter of the alphabet with one number (26 letters)? (b) Write your first name, but encoded letter by letter in binary.

a) $\log_2(26) = 4.7$ but in practice you would need $\boxed{5 \text{ bits}}$

case sensitive

B) Eli 0101 1100 1001

2. Repeat the prior exercise with hexedecimal numbers instead of binary ones.

b) Eli 45 6C 69

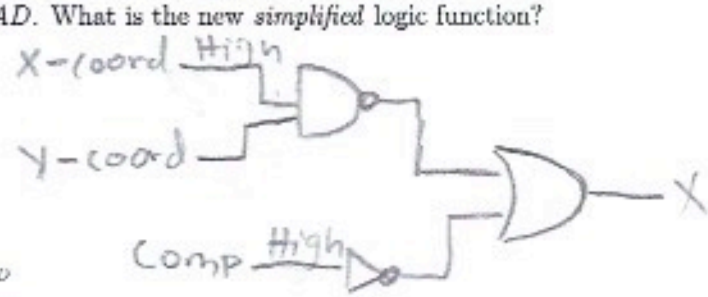
3 Chapter 3 - Logic Gates

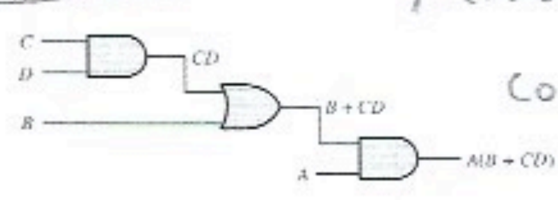
1. (a) In a certain manufacturing process, electrical components are automatically placed on a printed ciruit board (PCB). Before insertion, the tool must have the correct x-coordinate, y-coordinate, and the component must be ready. Each condition is a HIGH, and the inserter proceeds on LOW. Design a circuit that implements this process. (b) Suppose the inserter replaces A in Fig. 1 with AD. What is the new *simplified* logic function?

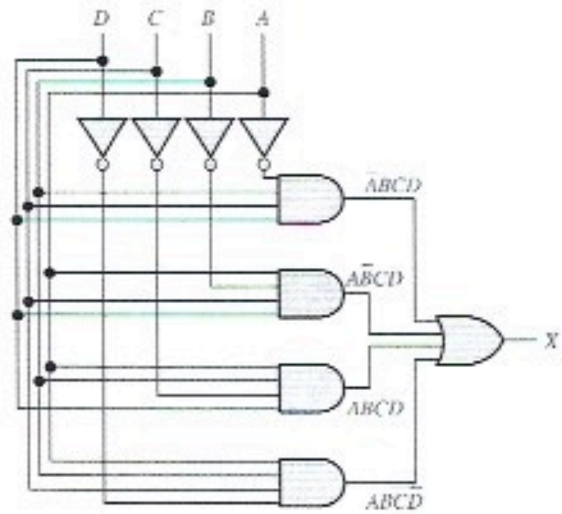
B) $AD(B+CD)$

$\boxed{ADB + AC}$

A)







Simplified circuit for an OR Gate

$X = A+B+C+D$

Figure 2: Example circuit for chapter 5.

4 Chapter 4 - Boolean Algebra and Logic Simplification

1. Map the expression $X = A + \bar{C}D + AC\bar{D} + \bar{A}BC\bar{D}$ onto a Karnaugh map, group the true states, and develop the simplified logic expression for the output X.

$C\bar{D}(\bar{B}+B) \rightarrow ACB\bar{B} + ABC\bar{B}$

$CD(\bar{B}+B)(A+A) + \bar{C}D\bar{B} +$

$CD\bar{C} + \bar{C}DB(A+A)$

$\bar{C}D\bar{B}A + \bar{C}D\bar{B}\bar{A} + \bar{C}DBA + CDBA$

CD \ AB	00	01	11	10
00	1	1		
01		1	1	
11		1	1	1
10	1	1	1	1

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5 Chapter 5 - Combinational Logic Analysis

1. In Fig. 2, a logic function is shown that outputs 1 if exactly three inputs are 1. (a) Develop the truth table (true states only). (b) Determine if it can be simplified.

$X = \bar{A}BCD + A\bar{B}CD + AB\bar{C}D + ABC\bar{D}$

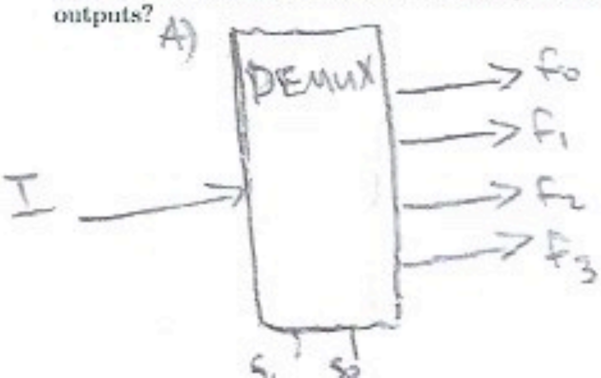
$X = (\overline{\bar{A}\bar{B}\bar{C}})C + \overline{\bar{A}\bar{B}\bar{C}} + D$

A	B	C	D	X
0	1	1	1	$\bar{A}BCD$
1	0	1	1	$A\bar{B}CD$
1	1	0	1	$AB\bar{C}D$
1	1	1	0	$ABC\bar{D}$

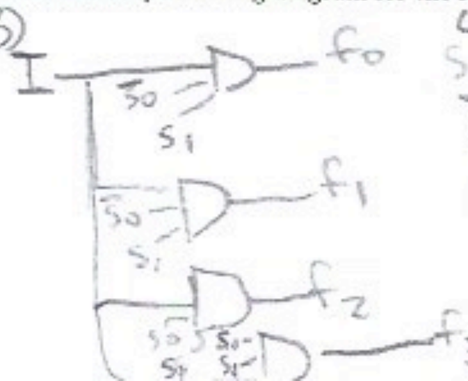
6 Chapter 6 - Functions of Combinational Logic

1. Suppose you have a *counter* that accepts a clock signal as input, and has two outputs that cycle between 00, 01, 10, and 11. (a) Draw a circuit connecting the 2-bit counter to the data select lines of a 1-to-4 demultiplexer. (b) Now connect also the counter output to a 2-bit *parity checker* (XOR gate), and let the output of the parity checker be the data input to the demultiplexer. (c) What is the output timing diagram for the four demultiplexer outputs?

A)



B)



C)

$S_1 S_0$	f
0 0	f_0
0 1	f_1
1 0	f_2
1 1	f_3

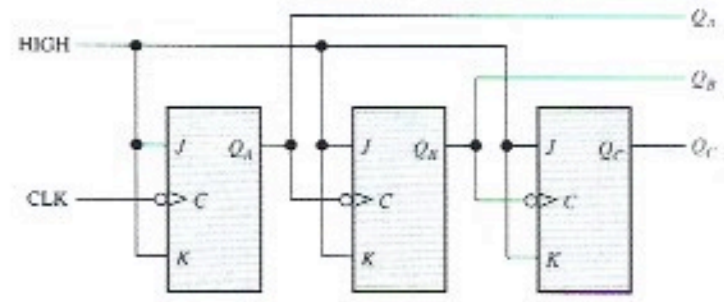
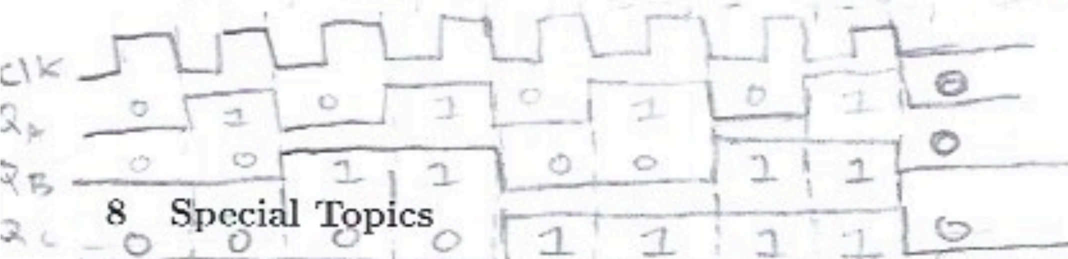


Figure 3: Example circuit for chapter 7.

7 Chapter 7 - Latches, Flip-flops, and Timers

1. Remember the *counter* mentioned in the previous problem? Consider Fig. 3. Determine the output waveforms in relation to the clock for Q_A, Q_B, and Q_C, and show that $Q_C Q_B Q_A$ is the binary sequence.

The outputs go through the binary sequence 000, 001, 010, 011, 100, 101, 110, and 111



8 Special Topics

1. **Two bonus points:** Determine the Fourier series for the sawtooth wave, which is just $f(x) = x$ from 0 to 2π, after which it goes back to zero and repeats itself.

$f(t) = \frac{A}{T} t$

$0 < t < T$

$$f(x) = \frac{1}{T} \quad w = 2\pi f = \frac{2\pi}{T}$$

If it repeats itself then the Fourier series of this function is $\int_{-\infty}^{\infty}$

$$f(t) = a_0 + \sum_{n=1}^{\infty} \left[a_n \cos \Omega t + b_n \sin \Omega t \right]$$

4.

$ABCD + ABC\bar{D} + AB\bar{C}D + A\bar{B}CD + ABCD +$

$ABC\bar{D} + A\bar{B}\bar{C}D + A\bar{B}\bar{C}\bar{D} + A\bar{B}\bar{C}D + A\bar{B}\bar{C}D +$

$AB\bar{C}D + \bar{A}B\bar{C}D + A\bar{B}C\bar{D} + ABC\bar{D} + \bar{A}BC\bar{D}$