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CSS 422

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Homework Problem Set #1

From <https://faculty.washington.edu/aberger/CSS422W09/Homework/Homework%201/CSS422W09.htm>

Problem #1- Convert the decimal number 92,892 to base 17. Note that the numbers in a base 17 system would be 0 through G. Be sure to show your work.

1. Find the largest value of the base, raised to a power, that is less than 92,892

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 170 = 1 | 171 = 17 | 172 = 289 | 173 = 4, 913 | 174 = 83,521 |

1. Divide the number by 174 to get the most significant digit. Store the remainder. While the remainder is > 0, divide it by decreasing powers of 17 to get less significant digits:  
     
   92,892 / 174 (83,521) = 1 (mod 9,371)  
   9,371 / 173 (4,913) = 1 (mod 4,458)  
   4,458 / 172 (289) = F (mod 123)  
   123 / 171 (17) = 7 (mod 4)  
   4 / 170 (1) = 4 (mod 0)  
     
   **Answer: 11F74**

Problem #2- Draw the circuit for a 2-input AND gate using CMOS transistors. Hint: use the diagram in Figure 2.16 as a starting point.

A CMOS AND gate combines a NAND gate (two P-type transistors in parallel between Vcc and output and two N-type transistors in series between ground and inputs) and a NOT gate (an inverter; one P-type and one N-type transistor in parallel).

Problem #3- The speed of light in free space is approximately 3 x 1010 cm per second. However, the speed of light on an integrated circuit chip is only 1/2 that of free space. The path from point A to point B on the figure shown below represents the longest signal path on the chip. The red square represents a booster amplifier which introduces an additional 8 picosecond propagation delay. In engineering units, what is the time delay for a signal traveling along the path from A to B?

**Speed of light on-chip:** cm/sec

**Time required to travel 1 cm:** sec

**Horizontal length:** 13.6 cm

**Horizontal scale:** = 0.135

**Vertical length:** 13.8 cm

**Vertical scale:** = 0.132

**Scaled length of signal path:** (13.6 \* 0.135 + 13.8 \* 0.132) = 1.836 + 1.822 = 3.66 cm or cm

**Time delay for signal travelling from point A to point B:**

\* sec + 8 \* sec

simplified:

**+ 8 \* sec**

Problem #4- Design the digital logic for a new home thermostat.

1. Create a truth table for the thermostat, listing all of the input states and the resultant output states.

**Rules:**

* If the heat exchanger is hot and heating is enabled, run the fan. (if (B and E), b = 1)
* If the room is hot (setpoint 1) and listening to setpoint 1 and cooling is enabled, run the compressor and the fan. (if A\*D\*'E, a = 1, b = 1)
* If the room is hot (setpoint 2) and listening to setpoint 2 and cooling is enabled, run the compressor and the fan. (if C\*'D\*'E, a = 1, b = 1)
* If the room is cold (setpoint 1) and listening to setpoint 1 and heating is enabled, run the burner. (if 'A\*D\*E, c = 1)
* If the room is cold (setpoint 2) and listening to setpoint 2 and heating is enabled, run the burner. (if 'C\*'D\*E, c = 1)

**Truth table:**

5 inputs: **25 (32)** possible combinations.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **A** | **B** | **C** | **D** | **E** | **a** | **b** | **c** |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 |
| 0 | 0 | 1 | 0 | 0 | 1 | 1 | 0 |
| 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 |
| 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| 0 | 0 | 1 | 1 | 1 | 0 | 0 | 1 |
| 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 1 | 0 | 0 | 1 | 0 | 1 | 1 |
| 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| 0 | 1 | 0 | 1 | 1 | 0 | 1 | 1 |
| 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 |
| 0 | 1 | 1 | 0 | 1 | 0 | 1 | 0 |
| 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 |
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| 1 | 0 | 0 | 1 | 0 | 1 | 1 | 0 |
| 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| 1 | 0 | 1 | 0 | 0 | 1 | 1 | 0 |
| 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 |
| 1 | 0 | 1 | 1 | 0 | 1 | 1 | 0 |
| 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 |
| 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 1 | 0 | 0 | 1 | 0 | 1 | 1 |
| 1 | 1 | 0 | 1 | 0 | 1 | 1 | 0 |
| 1 | 1 | 0 | 1 | 1 | 0 | 1 | 0 |
| 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 |
| 1 | 1 | 1 | 0 | 1 | 0 | 1 | 0 |
| 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 |
| 1 | 1 | 1 | 1 | 1 | 0 | 1 | 0 |

1. Create a Karnaugh Map for each of the output variables and simplify the equations for each of the output variables.

3 five variable K-maps follow, using the overlay, rather than reflection, method. Overlaps are highlighted in grayscale.

Variable **a:**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **AB / CDE** | **000** | **001** | **011** | **010** | **100** | **101** | **111** | **110** |
| **00** |  |  |  |  | 1 |  |  |  |
| **01** |  |  |  |  | 1 |  |  |  |
| **11** |  |  |  | 1 | 1 |  |  | 1 |
| **10** |  |  |  | 1 | 1 |  |  | 1 |

Variable **b:**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **AB / CDE** | **000** | **001** | **011** | **010** | **100** | **101** | **111** | **110** |
| **00** |  |  |  |  | 1 |  |  |  |
| **01** |  | 1 | 1 |  | 1 | 1 | 1 |  |
| **11** |  | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **10** |  |  |  | 1 | 1 |  |  | 1 |

Variable **c:**

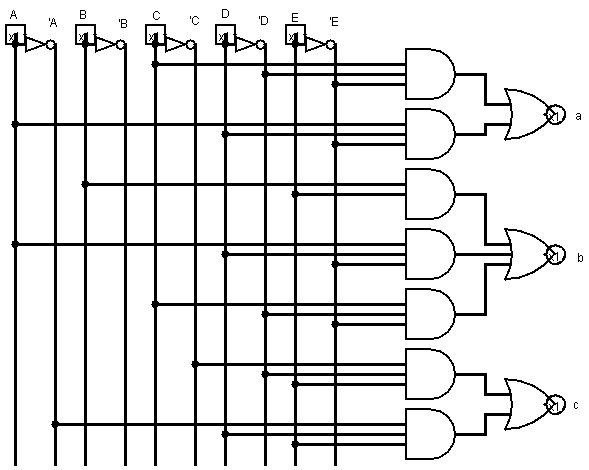
|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **AB / CDE** | **000** | **001** | **011** | **010** | **100** | **101** | **111** | **110** |
| **00** |  | 1 | 1 |  |  |  | 1 |  |
| **01** |  | 1 | 1 |  |  |  | 1 |  |
| **11** |  | 1 |  |  |  |  |  |  |
| **10** |  | 1 |  |  |  |  |  |  |

1. Write the simplified equations and then create the gate diagrams for the circuit.

**a** = C'D'E + AD'E

**b** = BE + AD'E + C'D'E

**c** = 'C'DE + 'ADE



Problem #5:

The quarterback of the high school football team in "Starship Troopers" is named Dizzy Flores.