ECE380 Digital Logic

Introduction to Logic Circuits:
Design Examples

Design examples

- Logic circuits provide a solution to a problem
- Some may be complex and difficult to design
- Regardless of the complexity, the same basic design issues must be addressed
  1. Specify the desired behavior of the circuit
  2. Synthesize and implement the circuit
  3. Test and verify the circuit

Three-way light control

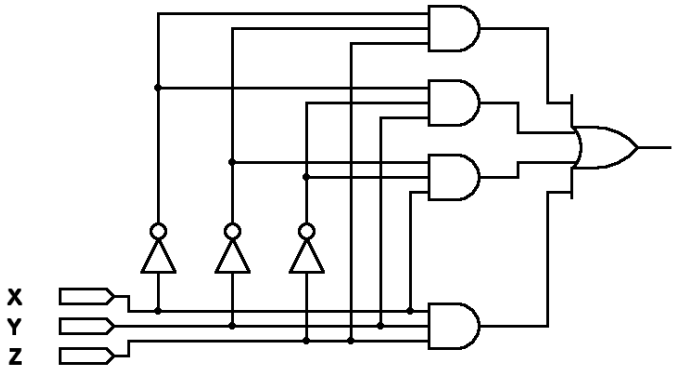
- Assume a room has three doors and a switch by each door controls a single light in the room.
  - Let x, y, and z denote the state of the switches
  - Assume the light is off if all switches are open
  - Closing any switch turns the light on. Closing another switch will have to turn the light off.
  - Light is on if any one switch is closed and off if two (or no) switches are closed.
  - Light is on if all three switches are closed

Three-way light control

x	*y*	*z*	*f*
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	0
1	0	0	1
1	0	1	0
1	1	0	0
1	1	1	1

$$f(x,y,z) = m_1 + m_2 + m_4 + m_7$$
$$f(x,y,z) = x'y'z + x'yz' + xy'z' + xyz$$

This is the simplest sum-of-products form.



Multiplexer circuit

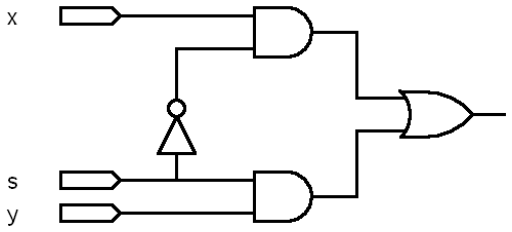
- In computer systems it is often necessary to choose data from exactly one of a number of sources
  - Design a circuit that has an output (f) that is exactly the same as one of two data inputs (x,y) based on the value of a control input (s)
    - If s=0 then f=x
    - If s=1 then f=y
  - The function f is really a function of three variables (s,x,y)
  - Describe the function in a three variable truth table

Multiplexer circuit

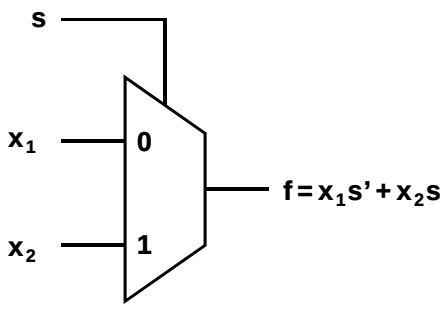
s	*x*	*y*	*f*
0	0	0	0
0	0	1	0
0	1	0	1
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	0
1	1	1	1

convenient to put control signal on left

$$f(s,x,y) = m_2 + m_3 + m_5 + m_7$$
$$f(s,x,y) = s'xy' + s'xy + sx'y + sxy$$
$$f(s,x,y) = s'x(y' + y) + sy(x' + x)$$
$$f(s,x,y) = s'x + sy$$



Multiplexer circuit



Graphical symbol

s	$f(s,x_1,x_2)$
0	x_1
1	x_2

Compact truth table

Car safety alarm

- Design a car safety alarm considering four inputs
  - Door closed (D)
  - Key in (K)
  - Seat pressure (S)
  - Seat belt closed (B)
- The alarm (A) should sound if
  - The key is in and the door is not closed, or
  - The door is closed and the key is in and the driver is in the seat and the seat belt is not closed

Car safety alarm

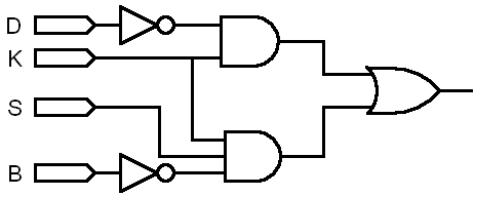
D K S B	A
0 0 0 0	0
0 0 0 1	0
0 0 1 0	0
0 0 1 1	0
0 1 0 0	1
0 1 0 1	1
0 1 1 0	1
0 1 1 1	1
1 0 0 0	0
1 0 0 1	0
1 0 1 0	0
1 0 1 1	0
1 1 0 0	0
1 1 0 1	0
1 1 1 0	1
1 1 1 1	0

$A(D,K,S,B) = \Sigma m(4,5,6,7,14)$

$A(D,K,S,B) = D'KS'B' + D'KS'B + D'KSB' + D'KSB + DKSB'$

$= D'KS' + D'KS + KSB'$

$= D'K + KSB'$



Adder circuit

- Design a circuit that adds two input bits together (x,y) and produces two output bits (s and c)
  - S: sum bit
    - x=0, y=0 => s=0
    - x=0, y=1 => s=1
    - x=1, y=0 => s=1
    - x=1, y=1 => s=0
  - C: carry bit
    - x=0, y=0 => c=0
    - x=0, y=1 => c=0
    - x=1, y=0 => c=0
    - x=1, y=1 => c=1

Majority circuit

- Design a circuit with three inputs (x,y,z) whose output (f) is 1 only if a majority of the inputs are 1
  - Construct a truth table
  - Write a standard sum-of-products expression for f
  - Draw a circuit diagram for the sum-of-products expression
  - Minimize the function using algebraic manipulation
    - During your minimization you can use any Boolean theorem, but leave the result in sum-of-products form (generate a minimum sum-of-products expression)
  - Draw the minimized circuit