Digital Logic Basics

Last updated 10/10/24

These slides introduce digital logic concepts

Digital Logic Basics

- Digital Logic
  - Defining an expression(operand) as True or False
  - Logical
    - In the digital world we indicate T with a logical value 1
    - In the digital world we indicate F with the logical value 0
  - Physical
    - These are signals – voltages on a wire
    - 1 is defined as the positive voltage supply value (V_{DD})
      - 5V, 3.3V. 2.5V, …
    - 0 is defined as Gnd (0V)

Digital Logic Basics

- Digital Logic
  - Logic Expression
    - Operation Operand → 1(T) or 0(F)
    - Operand Operation Operand → 1(T) or 0(F)

  - More complex expressions are built out of these two basic operations

    ((Operand Operation Operand) Operation (Operand Operation Operand))

    (((Operand Operation Operand) Operation Operand) Operation Operand)

Always remember, 1 and 0 are abstractions
The actual values on the wires are V_{DD} and Gnd

Digital Logic Basics

- NOT – flips (negates) the value of the input
  - 1 → 0 or 0 → 1
  - not operand
  - ~ operand
  - $\overline{\text{operand}}$

A = 1
B = 0

not A → 0
~ B → 1

not (not A) → 1

$\overline{\sim A}$ → 1

NOT

A	Not A
0	1
1	0

Always remember, 1 and 0 are abstractions
The actual values on the wires are V_{DD} and Gnd

Digital Logic Basics

- OR – evaluates as 1(T) if either input is 1 (T)
  - op1 or op2
  - op1 | op1
  - op1 + op2

A = 1
B = 0
C = 1

A or B → 1
A | C → 1
B + C → 1

(not A) | B → 0

OR

A	B	A or B
0	0	0
0	1	1
1	0	1
1	1	1

Always remember, 1 and 0 are abstractions
The actual values on the wires are V_{DD} and Gnd

Digital Logic Basics

- NOR – evaluates as 0(T) if either input is 1 (T)
  - This is the NOT of an OR
  - op1 nor op2
  - $\overline{\text{op1} \mid \text{op1}}$
  - $\overline{\text{op1} + \text{op2}}$

A = 1
B = 0
C = 0

A nor B → 0
$\overline{A \mid C}$ → 0
$\overline{B + C}$ → 1

$\overline{(\text{not } A) \mid B}$ → 1

NOR

A	B	$\overline{A \text{ or } B}$
0	0	1
0	1	0
1	0	0
1	1	0

Always remember, 1 and 0 are abstractions
The actual values on the wires are V_{DD} and Gnd

Digital Logic Basics

- AND – evaluates as 1(T) if both inputs are 1(T)
  - op1 and op2
  - op1 & op2
  - op1op2, (op1)(op2)

A = 1
B = 0
C = 1

A and B → 0
A & C → 1
BC → 0

A & (not B) → 1

AND

A	B	A and B
0	0	0
0	1	0
1	0	0
1	1	1

Always remember, 1 and 0 are abstractions
The actual values on the wires are V_{DD} and Gnd

Digital Logic Basics

- NAND – evaluates as 0(F) if both inputs are 1(T)
  - This is the NOT of an AND
  - op1 nand op2
  - $\overline{\text{op1 \& op2}}$
  - $\overline{\text{op1op2}}$, $\overline{(\text{op1})(\text{op2})}$

A = 1
B = 0
C = 1

A nand B → 1
$\overline{\text{A \& C}}$ → 0
$\overline{\text{BC}}$ → 1

$\overline{\text{A \& (not B)}}$ → 0

NAND

A	B	$\overline{\text{A and B}}$
0	0	1
0	1	1
1	0	1
1	1	0

Always remember, 1 and 0 are abstractions
The actual values on the wires are V_{DD} and Gnd

Digital Logic Basics

- XOR – evaluates as 1(T) if an odd number of inputs are 1(T)
  - op1 xor op2
  - op1 ⊗ op2

A = 1
B = 0
C = 1

A xor B → 1
A ⊗ C → 0

A ⊗ (not B) → 0

XOR

A	B	A xor B
0	0	0
0	1	1
1	0	1
1	1	0

Always remember, 1 and 0 are abstractions
The actual values on the wires are V_{DD} and Gnd

Digital Logic Basics

- XNOR – evaluates as 0(F) if an odd number of inputs are 1(T)
  - This is the NOT of an XOR
  - op1 xnor op2
  - op1 ⊙ op2

A = 1
B = 0
C = 1

A xnor B → 0
A ⊙ C → 1
$\overline{A \otimes C}$ → 1

A ⊙ (not B) → 1

XNOR

A	B	$\overline{A \text{ xor } B}$
0	0	1
0	1	0
1	0	0
1	1	1

Always remember, 1 and 0 are abstractions
The actual values on the wires are V_{DD} and Gnd