CSSE2010

Welcome!

CSSE2010 / CSSE7201
Learning Lab 2

Logic Gates✓

http://responsewaresg.net

Session ID: CSSE2010EXT

School of Information Technology and Electrical Engineering
The University of Queensland

Today

Logic Gates

- Lecture revision ✓
- Introduction to Hardware ✓ / Simulation ✓ Logisim
- Circuit Schematics ✓
- Circuit Building → Logisim

What's the truth table for a 2 input XOR gate

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"Exclusive OR"

A.

A	B	X
0	0	**0**
0	1	**1**
1	0	**1**
1	1	**1**

B.

A	B	X
0	0	**1**
0	1	**0**
1	0	**0**
1	1	**1**

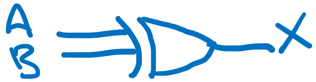
C.

A	B	X
0	0	**1**
0	1	**1**
1	0	**1**
1	1	**0**

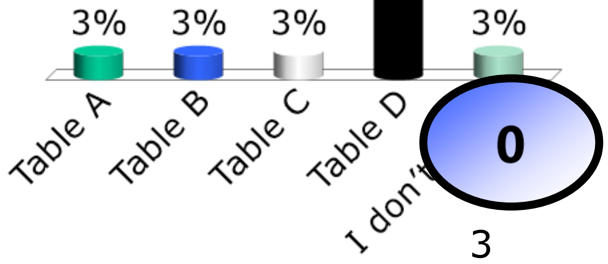
D.

A	B	X
0	0	**0**
0	1	**1**
1	0	**1**
1	1	**0**

E. I don't know.



n input XOR gate
→ 1 when odd number of 1 inputs
→ "odd function"



Which of the following circuits is equivalent to ...

$A \oplus B = AB' + A'B$

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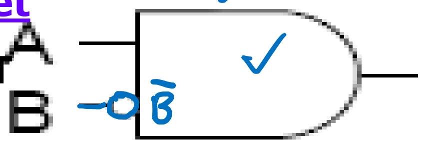
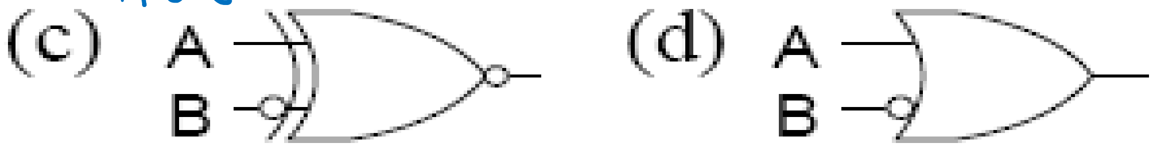


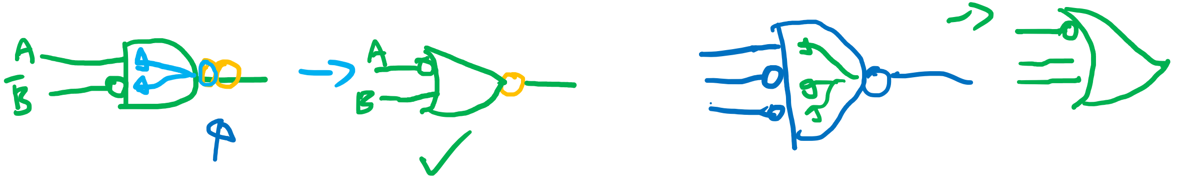
AND ↔ OR

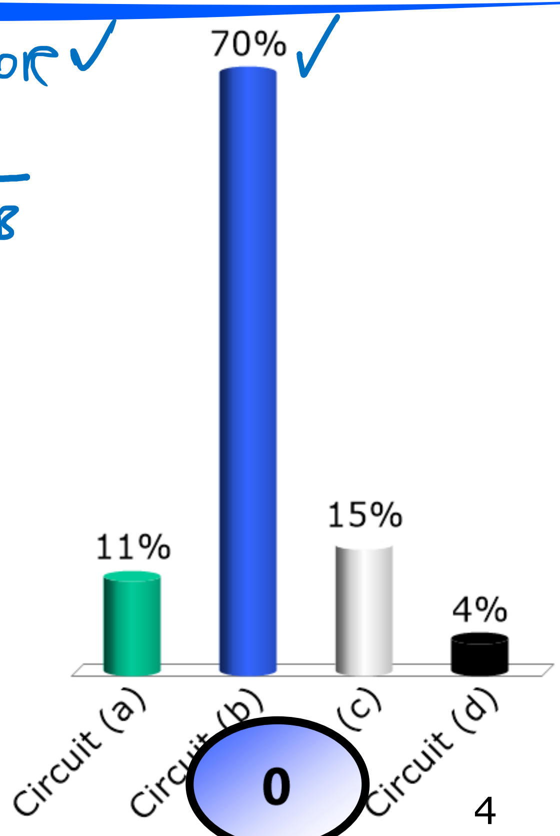
$X = A \cdot \bar{B}$

$= \overline{\bar{A} + B}$

$\overline{A \oplus \bar{B}} = AB' + A'B$







$(A+B)(A+C) = A.A + A.C + B.A + B.C = A + A.B + A.C + B.C = A(1+B+C) + B.C$
$= A(1) + B.C = A + B.C$

Boolean Identities (Reminder from lecture)

$AB = \overline{\bar{A}+\bar{B}}$

Name	AND form	OR form
Identity law	$1A = A$ $1 \times 5 = 5$	$0 + A = A$ $0+5=5$
Null law	$0A = 0$	$1 + A = 1$
Idempotent law	$AA = A$	$A + A = A$
Inverse law	$A\bar{A} = 0$	$A + \bar{A} = 1$
Commutative law	$AB = BA$	$A + B = B + A$
Associative law	$(AB)C = A(BC)$	$(A + B) + C = A + (B + C)$
* Distributative law	$A + BC = (A + B)(A + C)$	$A(B + C) = AB + AC$
Absorption law	$A(A + B) = A$	$A + AB = A$ $A(1+B) = A$
* De Morgan's law	$\overline{AB} = \bar{A} + \bar{B}$ $\overline{AB} \to \bar{A} + \bar{B}$	$\overline{A + B} = \bar{A}\bar{B} \to \bar{A} \cdot \bar{B}$

Invert inputs, invert outputs, flip operation   AND ⟺ OR

Objective

Main objective today:

Verify the functionality of a simple logic circuit either using a hardware circuit constructed with logic ICs or using simulations in Logisim software

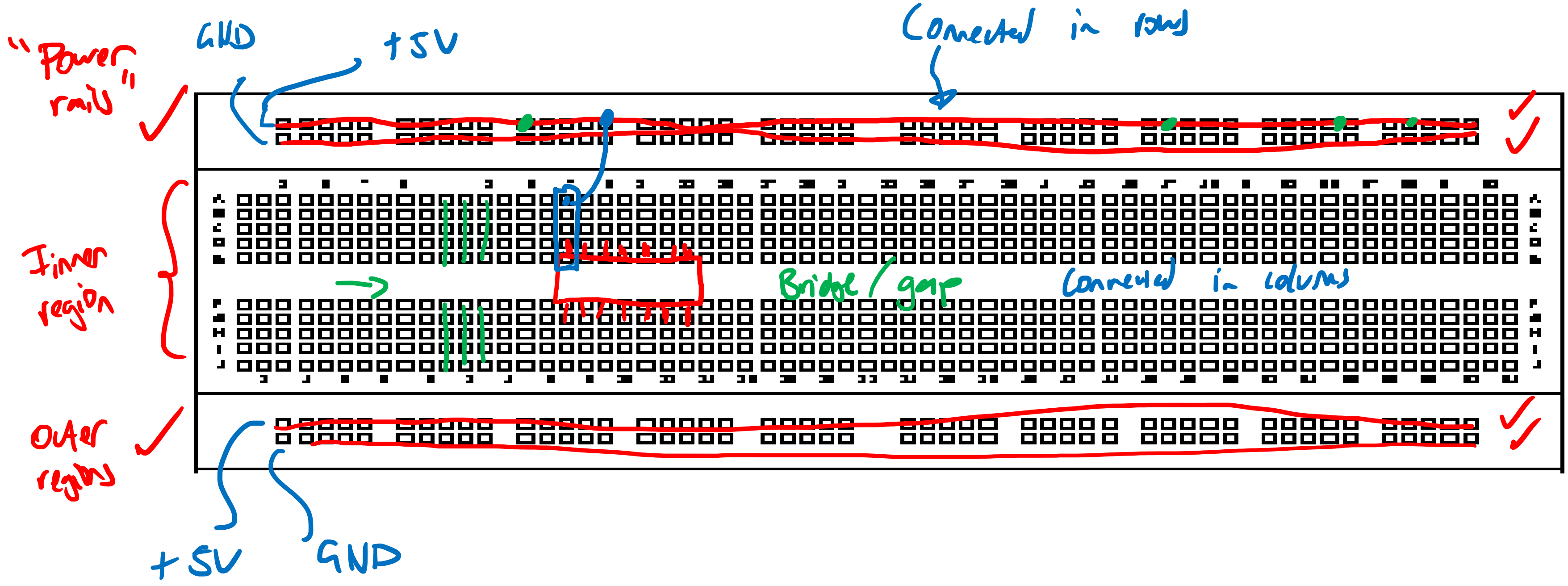
IN students: Use logic chips on your kit or use Logisim if you haven’t got your kit yet

EX students: Use Logisim software (it is free)

Hardware Overview

- Breadboard with IO board ✓
  - Be very careful with the USB connector ✗
- USB cable
- Hookup wire ✓
- Logic chip kit ✓
- IC Extractor

Breadboard


"Power rails"
GND
+5V
Connected in rows
Inner region
Bridge / gap
Connected in columns
Outer regions
+5V
GND

Logic Chips

Vcc / +5V

Top left pin

14 13 12 11 10 9 8

74HCT00

Series

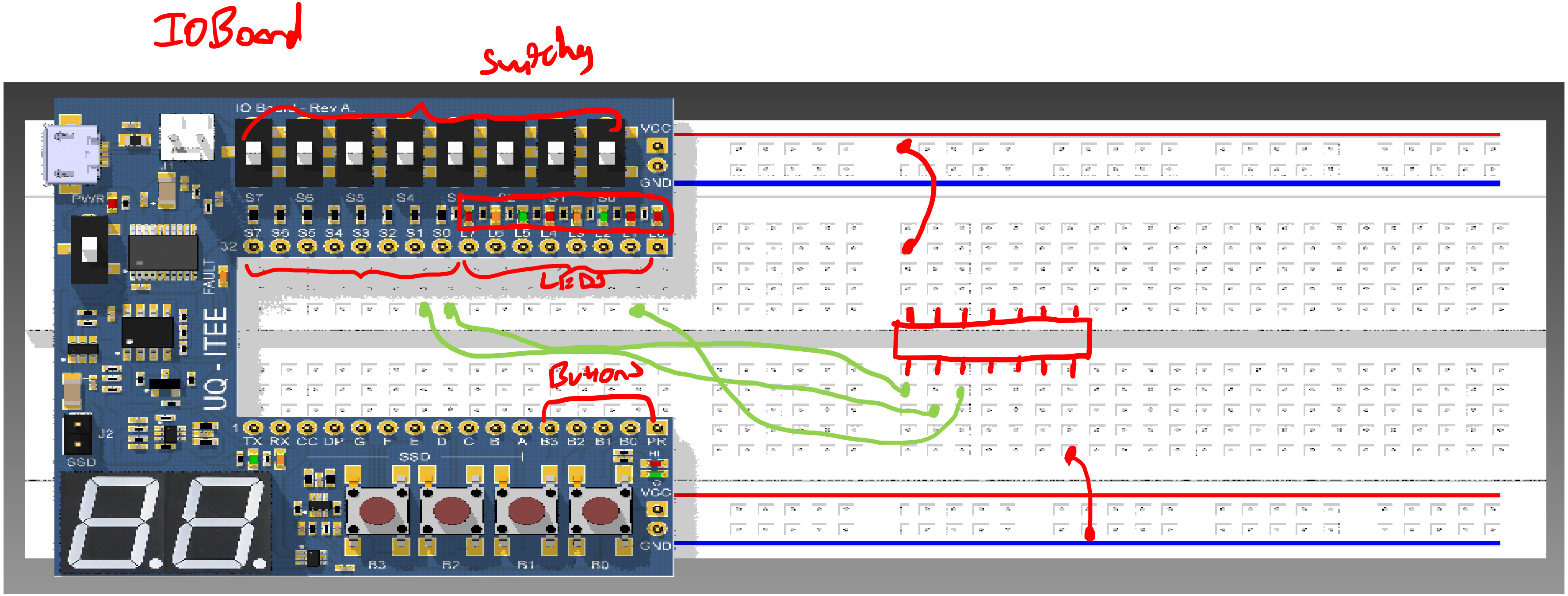
Part

1 2 3 4 5 6 7

"Pins"

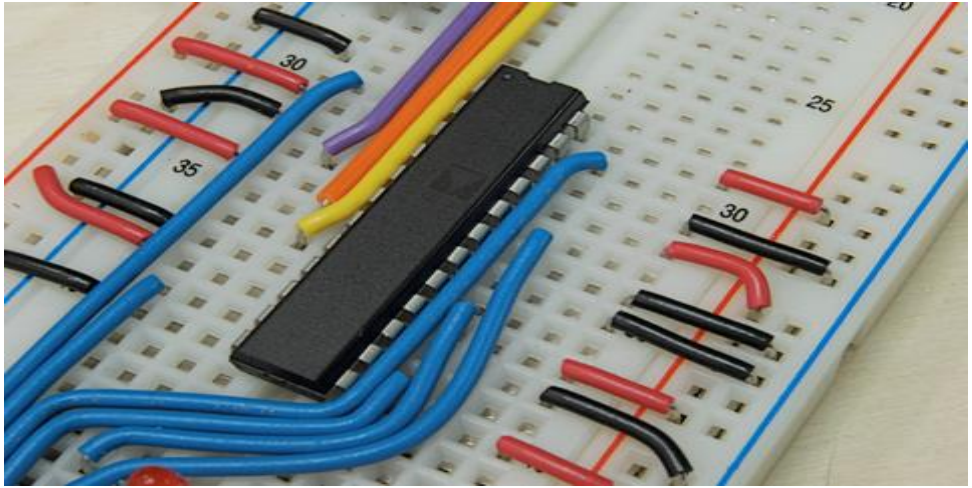
Bottom pin Ground

Breadboard with IO board

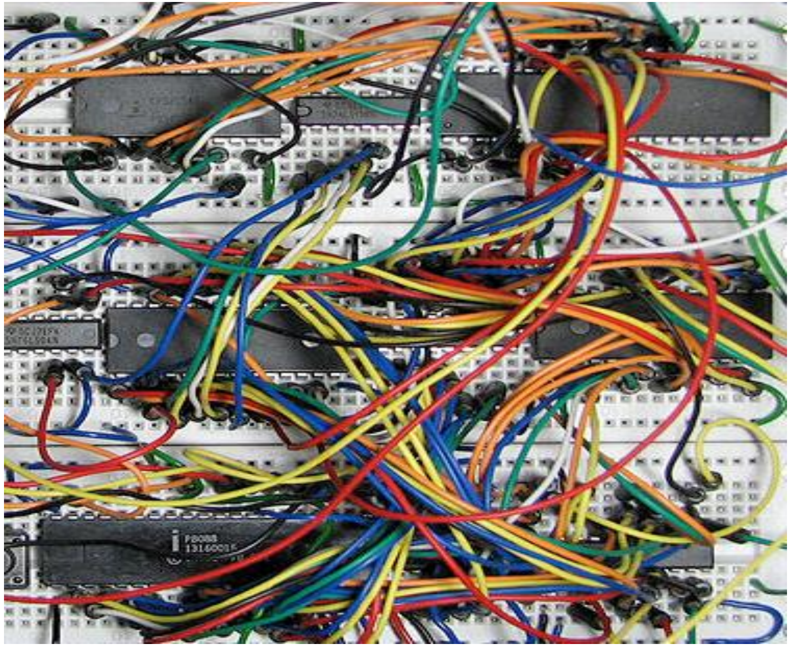


Wire neatly!

- Like this: ✓



Not this: ✗

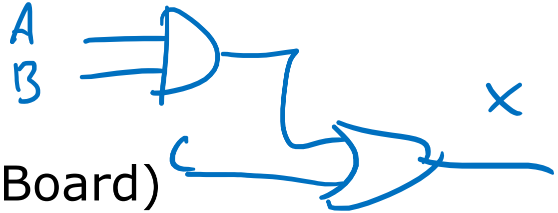


Device Information

- See course Blackboard site for
  - Guide to circuit schematics
    - Examples coming up
  - Device pinouts

Circuit Schematic Diagram

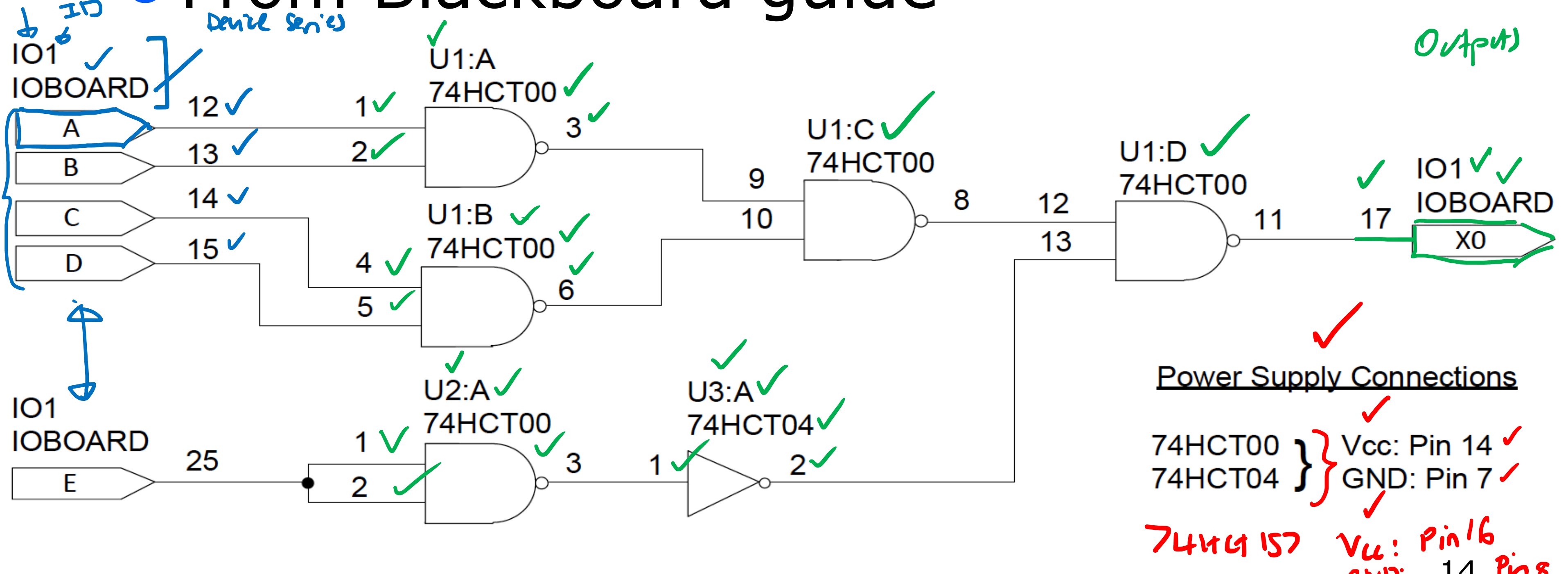
- More than a logic diagram, a circuit schematic tells you how to **build** the circuit ✓ Behaviour
- You'll need to draw these for pracs and exams ✓
- Schematics include
  - Labelled inputs ✓
  - Labelled outputs ✓
  - Labelled devices (logic chips & IO Board) ✓ ✓
    - Logic chips: U1, U2, U3, …
    - Label gates within a chip (:A, :B, :C) ✓
    - IOBoard: IO1 ✓
  - Power supply connections for logic chips ✓
  - Pin numbers ✓



Circuit Schematic Example

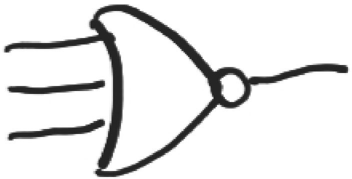
Device Type (IO)

- From Blackboard guide



Circuit Schematic Example

- 3 input NOR gate

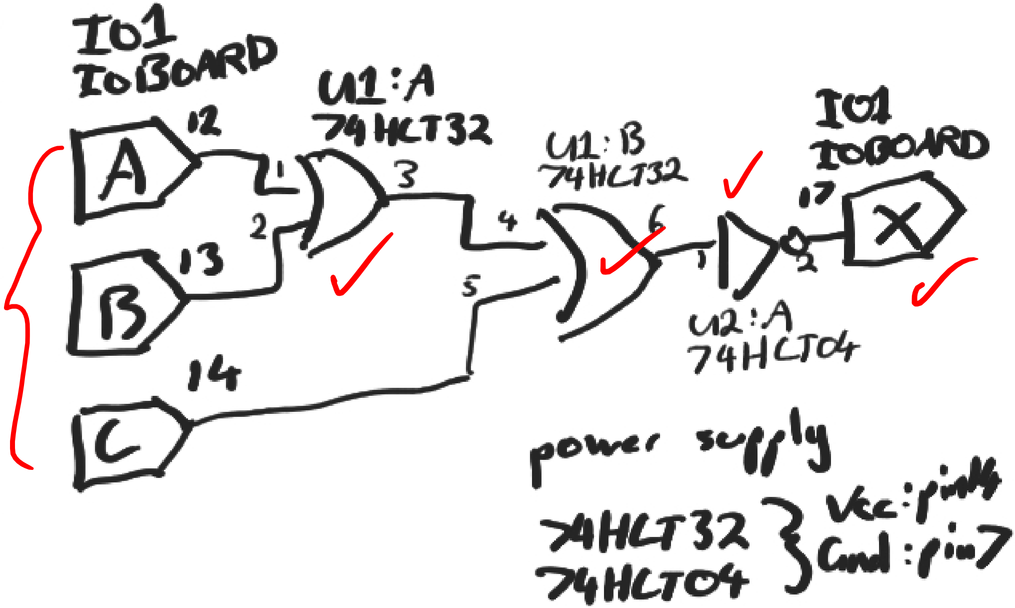


$$X = \overline{A+B+C}$$

logic diagram

truth table

A	B	C	X
0	0	0	1
0	0	1	0
0	1	0	0
0	1	1	0
1	0	0	0
1	0	1	0
1	1	0	0
1	1	1	0



- Now – wire this up or simulate in Logisim software & systematically determine truth table
- If you are testing on hardware, double check your circuit (especially power and ground) before you power it on

$Z = \bar{A}BC + A\bar{B}C + AB\bar{C} + ABC \rightarrow Z = \bar{A}BC + \underline{ABC} + A\bar{B}C + \underline{ABC} + AB\bar{C} + \underline{ABC}$

SOP

replicated terms (Idempotent law)

3-input Majority Function

Then group terms and apply distributive law

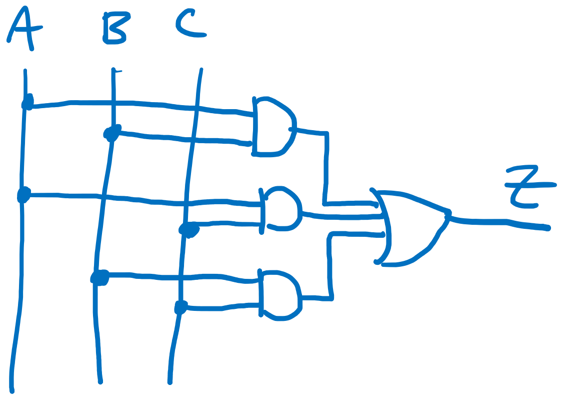
$Z = (\bar{A}+A)BC + (\bar{B}+B)AC + (\bar{C}+C)AB$

$= AB + AC + BC$

- True if at least two of the inputs (A,B,C) are true
  - ***Z=A.B + A.C + B.C***
- This function was shown in lecture 2 (though not in this form)
- Truth Table:

A	B	C	Z
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	1

Logic Diagram:



- Convert to NAND only circuit using Boolean algebra
- Draw circuit schematic - inputs are <u>switches</u>, output is <u>LED</u>
- Wire up circuit/simulate in Logisim and determine truth table
- Repeat using AND and OR gates