# ENGR 101
# Engineering Technology

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Victoria
UNIVERSITY OF WELLINGTON
Te Whare Wānanga
o te Ūpoko o te Ika a Māui
CAPITAL CITY UNIVERSITY

# Week 7 Lecture 12b

- Combinational circuit

- Assignment 2 – submit before midnight Monday
- Test 1 – Thursday 22 April (10:15 – 11:55am)

- Course web page:

  https://ecs.wgtn.ac.nz/Courses/XMUT101_2021T1/

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# Designing Combinational Logic Circuits

**Design Procedure:**

1. Set up truth table
2. Write AND term for each case where the output is HI
3. Write the SOP expression for the output
4. Simplify the expression
5. Implement the circuit

# Designing Combinational Logic Circuits

**Example 2:**

Design a circuit which will perform addition for 2 binary digits (x and y).

# 1) Set up truth table

- Recall that for binary addition we have: 0 + 0 = 0; 0 + 1 = 1; 1 + 0 = 1 and 1 + 1 = 0 with a carry of 1

| | Inputs | | Outputs | |
|---|---|---|---|---|
| | x | y | | |
| 1st row → | 0 | 0 | | |
| 2nd row → | 0 | 1 | | |
| 3rd row → | 1 | 0 | | |
| 4th row → | 1 | 1 | | |

# 1) Set up truth table

- Recall that for binary addition we have: 0 + 0 = 0; 0 + 1 = 1; 1 + 0 = 1 and 1 + 1 = 0 with a carry of 1

| | Inputs | | Outputs | |
|---|---|---|---|---|
| | x | y | Sum | Carry |
| 1st row → | 0 | 0 | 0 | 0 |
| 2nd row → | 0 | 1 | 1 | 0 |
| 3rd row → | 1 | 0 | 1 | 0 |
| 4th row → | 1 | 1 | 0 | 1 |

1) Set up truth table

2) Write AND term for each case where the output is HI

| | Inputs | | Outputs | |
|---|---|---|---|---|
| | x | y | Sum | Carry |
| 1st row → | 0 | 0 | 0 | 0 |
| 2nd row → | 0 | 1 | 1 | 0 |
| 3rd row → | 1 | 0 | 1 | 0 |
| 4th row → | 1 | 1 | 0 | 1 |

Sum = 1 → x'y

Sum = 1 → xy'

Carry = 1 → xy

# 3) Write the SOP expression for the output

Sum = x’y + xy’

Carry = xy

# 4) Simplify the expression – using K-Map

Sum = x'y + xy'

| | Y' | Y |
|---|---|---|
| X' | | 1 |
| X | 1 | |

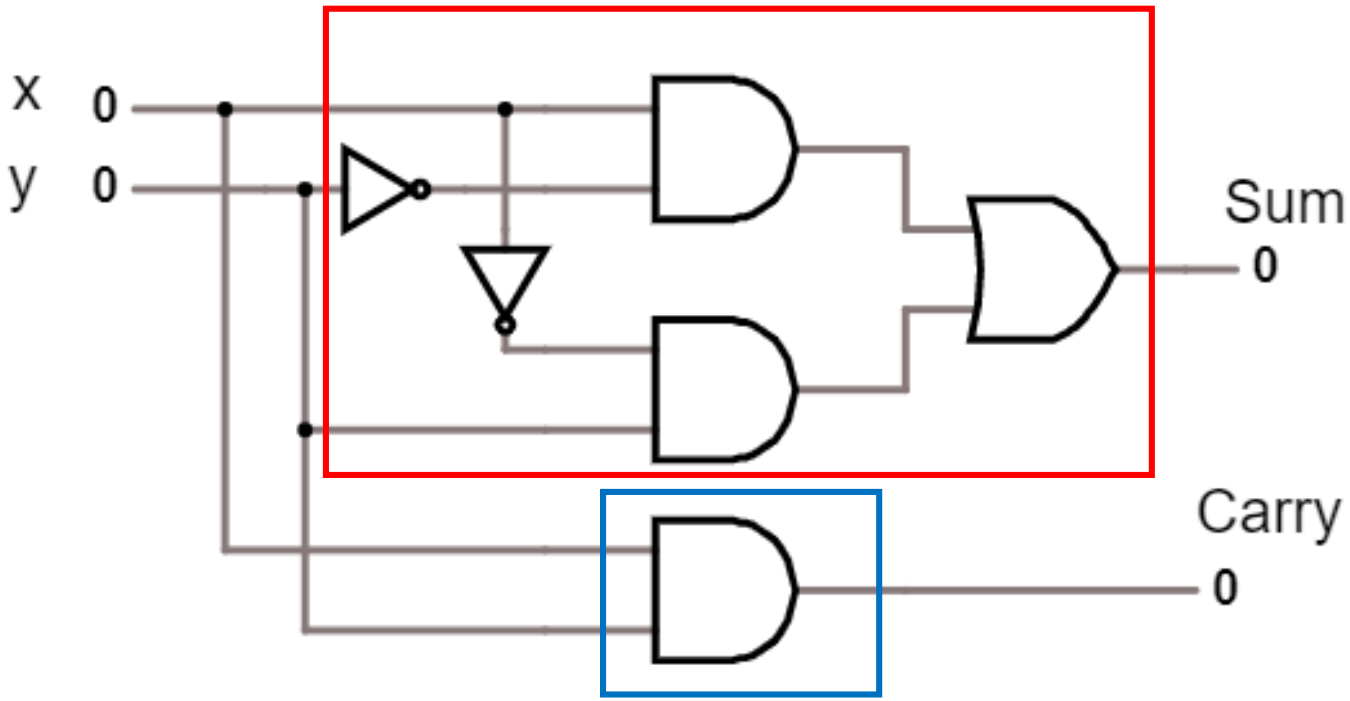
Carry = xy

| | Y' | Y |
|---|---|---|
| X' | | |
| X | | 1 |

# 5) Implement circuit:

Sum = x'y + xy'

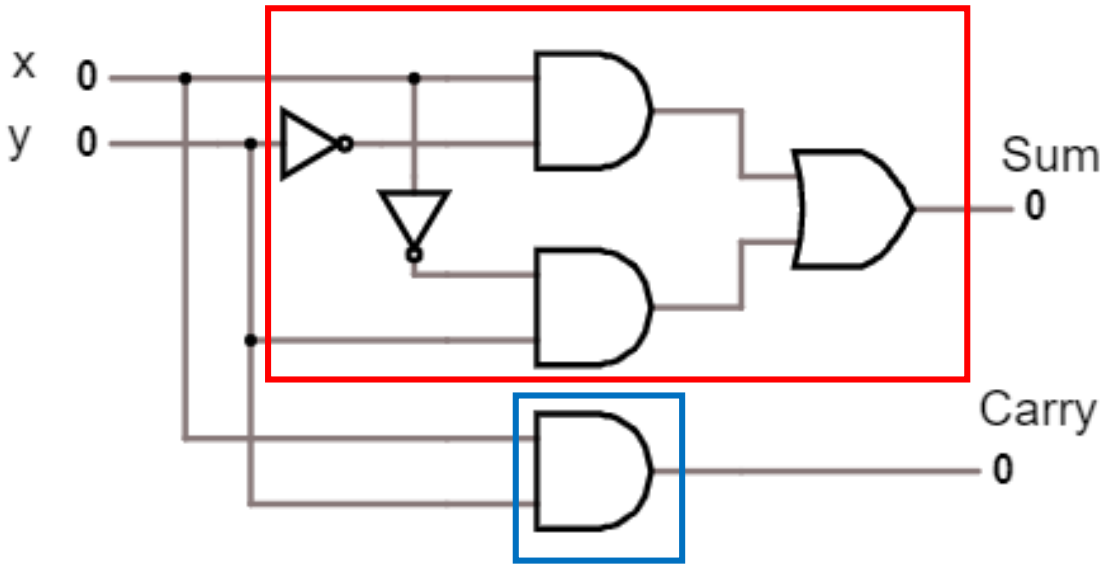
Carry = xy

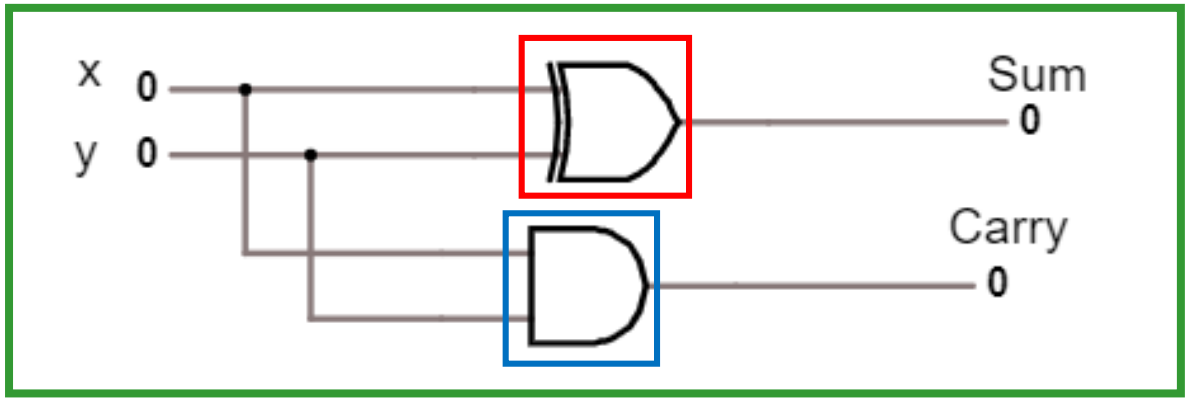


# 5) Implement circuit:

Sum = x'y + xy'

Carry = xy



# Designing Combinational Logic Circuits

**Example 2:**

Design a circuit which will perform addition for 3 binary digits (x, y and z).

# 1) Set up truth table

**Example 3:**

Design a circuit which will perform addition for 3 binary digits (x, y and z).

| | Inputs | | | Outputs | |
|---|---|---|---|---|---|
| | x | y | z | Sum | Carry |
| 1st row | 0 | 0 | 0 | | |
| 2nd row | 0 | 0 | 1 | | |
| 3rd row | 0 | 1 | 0 | | |
| 4th row | 0 | 1 | 1 | | |
| | 1 | 0 | 0 | | |
| | 1 | 0 | 1 | | |
| | 1 | 1 | 0 | | |
| | 1 | 1 | 1 | | |

# 1) Set up truth table

**Example 3:**

Design a circuit which will perform addition for 3 binary digits (x, y and z).

| | Inputs | | | Outputs | |
|---|---|---|---|---|---|
| | x | y | z | Sum | Carry |
| 1st row | 0 | 0 | 0 | 0 | 0 |
| 2nd row | 0 | 0 | 1 | 1 | 0 |
| 3rd row | 0 | 1 | 0 | 1 | 0 |
| 4th row | 0 | 1 | 1 | 0 | 1 |
| 5th row | 1 | 0 | 0 | 1 | 0 |
| 6th row | 1 | 0 | 1 | 0 | 1 |
| 7th row | 1 | 1 | 0 | 0 | 1 |
| 8th row | 1 | 1 | 1 | 1 | 1 |

# 1) Set up truth table

## 2) Write AND term for each case where the output is HI

| | Inputs | | | Outputs | | |
|---|---|---|---|---|---|---|
| | x | y | z | Sum | Carry | |
| | 0 | 0 | 0 | 0 | 0 | |
| 2nd row | 0 | 0 | 1 | 1 | 0 | x'y'z |
| 3rd row | 0 | 1 | 0 | 1 | 0 | x'yz' |
| 4th row | 0 | 1 | 1 | 0 | 1 | x'yz |
| 5th row | 1 | 0 | 0 | 1 | 0 | xy'z' |
| 6th row | 1 | 0 | 1 | 0 | 1 | xy'z |
| 7th row | 1 | 1 | 0 | 0 | 1 | xyz' |
| 8th row | 1 | 1 | 1 | 1 | 1 | xyz |

## 3) Write the SOP expression for the output

Sum = x’y’z + x’yz’ + xy’z’+ xyz

Carry = x’yz + xy’z + xyz’ + xyz

# 4) Simplify the expression – using K-Map

Sum = x'y'z + x'yz' + xy'z'+ xyz

| | z' | z |
|---|---|---|
| x'y' | | 1 |
| x'y | 1 | |
| xy | | 1 |
| xy' | 1 | |

Sum = z'(xy' + x'y) + z(xy' + x'y)'

Carry = x'yz + xy'z + xyz' + xyz

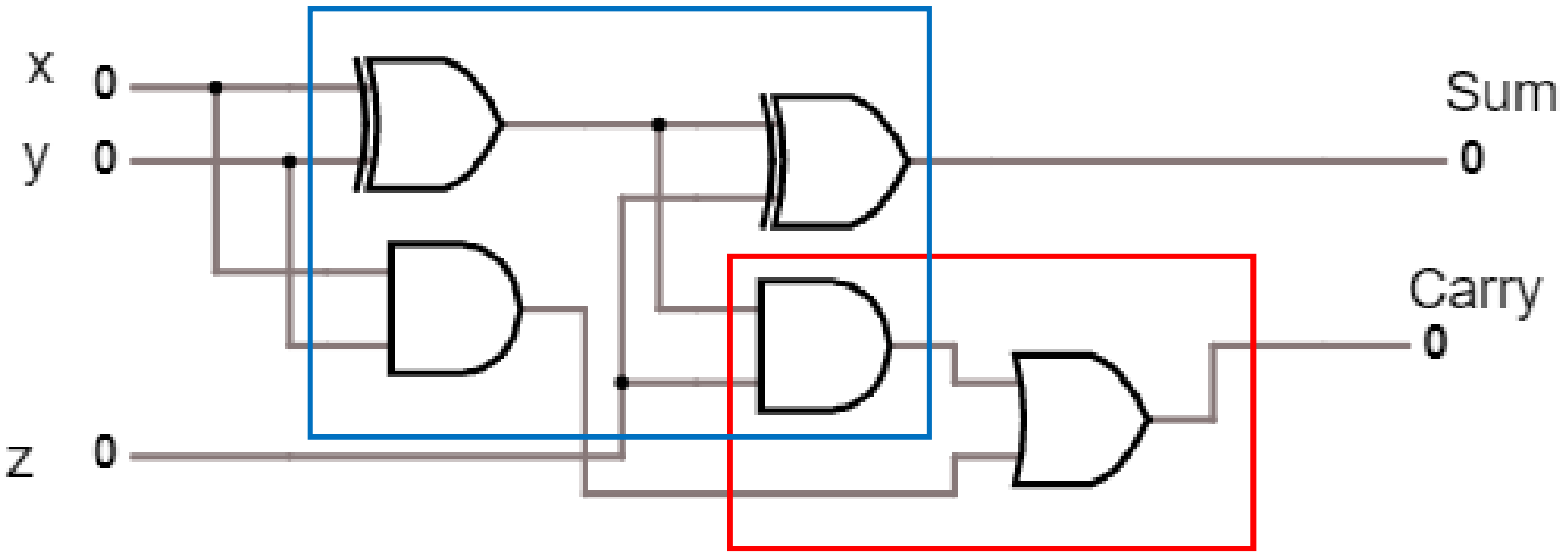
| | z' | z |
|---|---|---|
| x'y' | | |
| x'y | | 1 |
| xy | 1 | 1 |
| xy' | | 1 |

Carry = xy + yz + xz

# 5) Implement circuit:

Sum = z’(xy’ + x’y) + z(xy’ + x’y)’

Carry = xy + yz + xz



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