Digital Design

Week 3: Combinational Logic

Fenerbahce University

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Course Plan

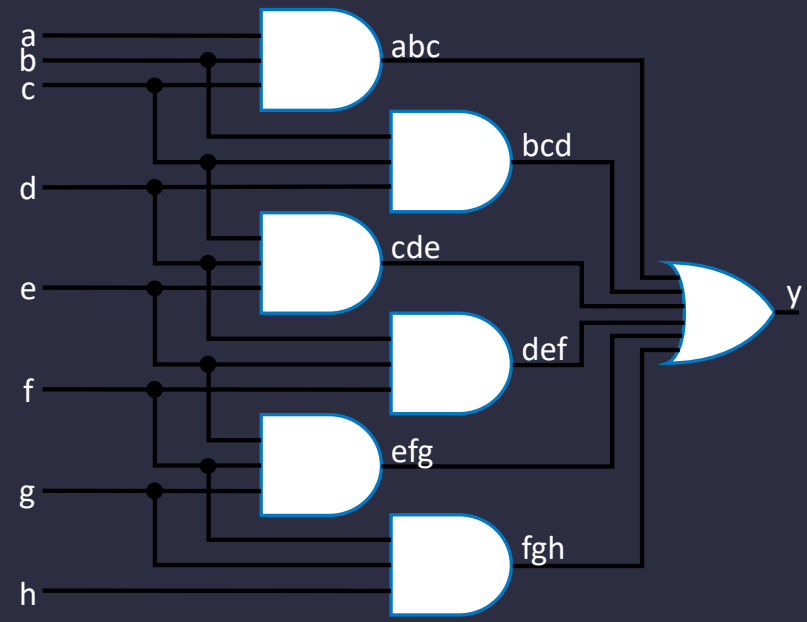
- Combinational Logic

Combinational Circuit Design Process

	Process	Explanation
Step 1	**Create Function**	A truth table or equation is created
Step 2	**Convert to Equation**	Convert truth table to equation. The equation is created by using output rows of 1
Step 3	**Create Circuit**	Draw the circuit from the equation

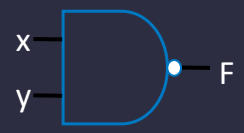
Example : 3 consecutive 1 finder circuits

- Example : Draw a circuit can find consecutive 1s out in a 8 bit number: abcdefgh
  - 000**111**01 → 1 10101011 → 0 **111**10000 → 1
  - **Step 1: Create the function**
    - Truth table or equation ?
      - The truth table will be very long as it will be 2^8=256 rows.
      - Equation : Identify and combine equations that will result 1
    - **y = abc + bcd + cde + def + efg + fgh**
  - **Step 2: Convert to equation** -- done
  - **Step 3: Create the circuit**



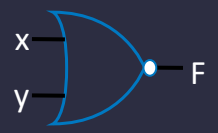
Logic Gates

NAND



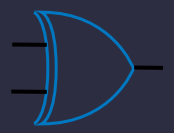
x	y	F
0	0	1
0	1	1
1	0	1
1	1	0

NOR



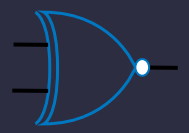
x	y	F
0	0	1
0	1	0
1	0	0
1	1	0

XOR

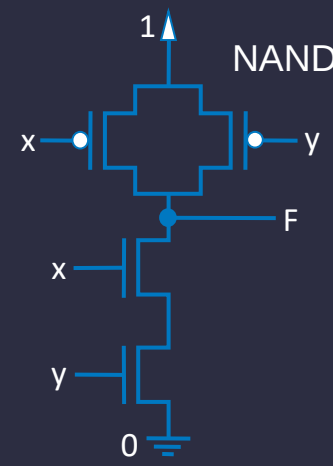


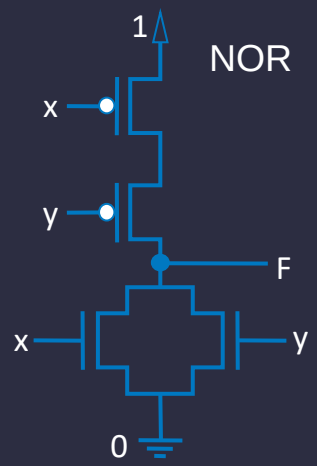
x	y	F
0	0	0
0	1	1
1	0	1
1	1	0

XNOR



x	y	F
0	0	1
0	1	0
1	0	0
1	1	1

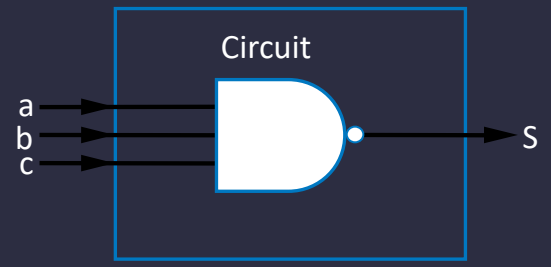




- NAND: NOT AND
- NOR: NOT OR
- XOR: Exclusive OR
- XNOR: NOT XOR

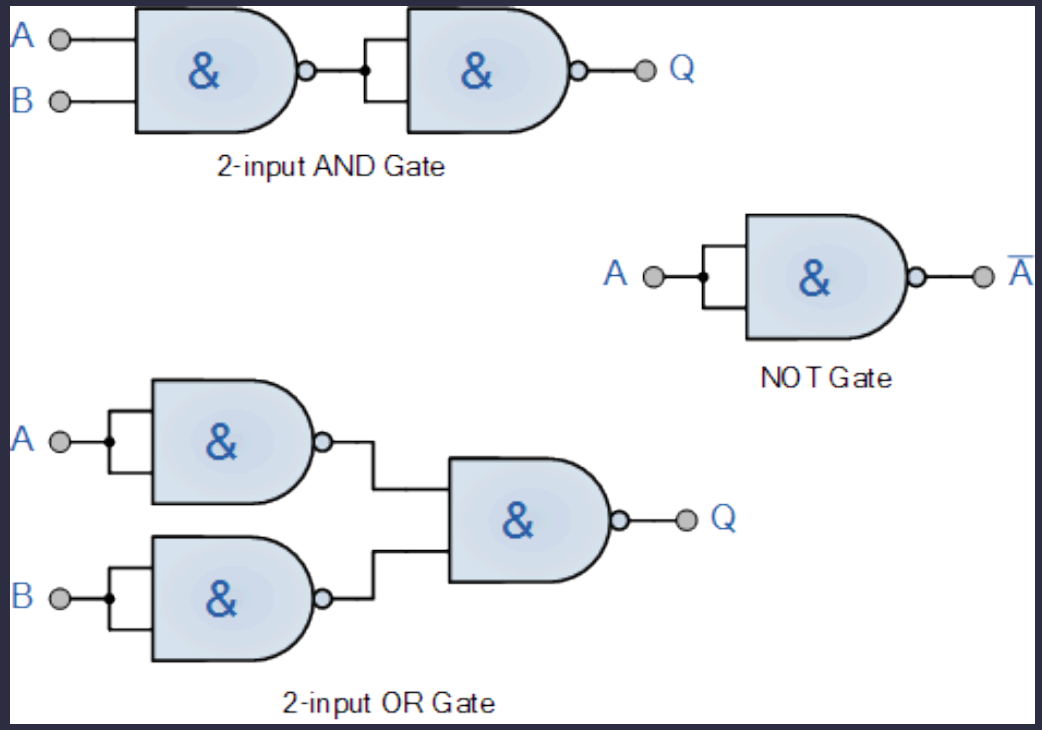
Logic Gates

- Aircraft sink usage light
  - S = (abc)'



NAND Gate

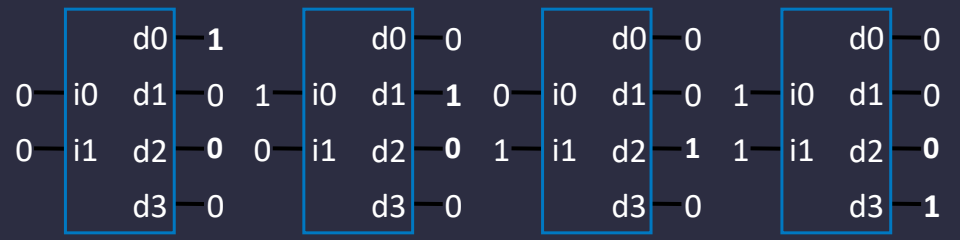
- In the digital design the NAND gate is using frequently.
- This is because all circuits can be made with NAND Gate.
  - NOTE
  - AND
  - OR

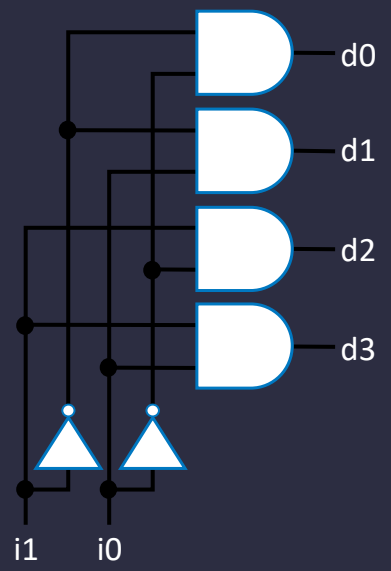


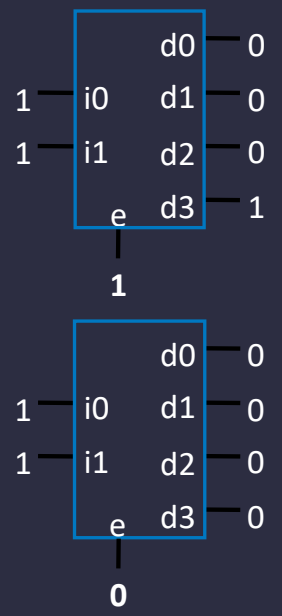
Decoder and MUX

- **Decoder** : Activates the pin corresponding to the number received in the input.

- 2 -input decoder: There are 4 possible inputs.
  - It has 4 outputs
- Enable with pin decoder
  - If e=0 , all outputs are 0
  - If e=1 , it behaves normally
- N input decoder: 2^n exit

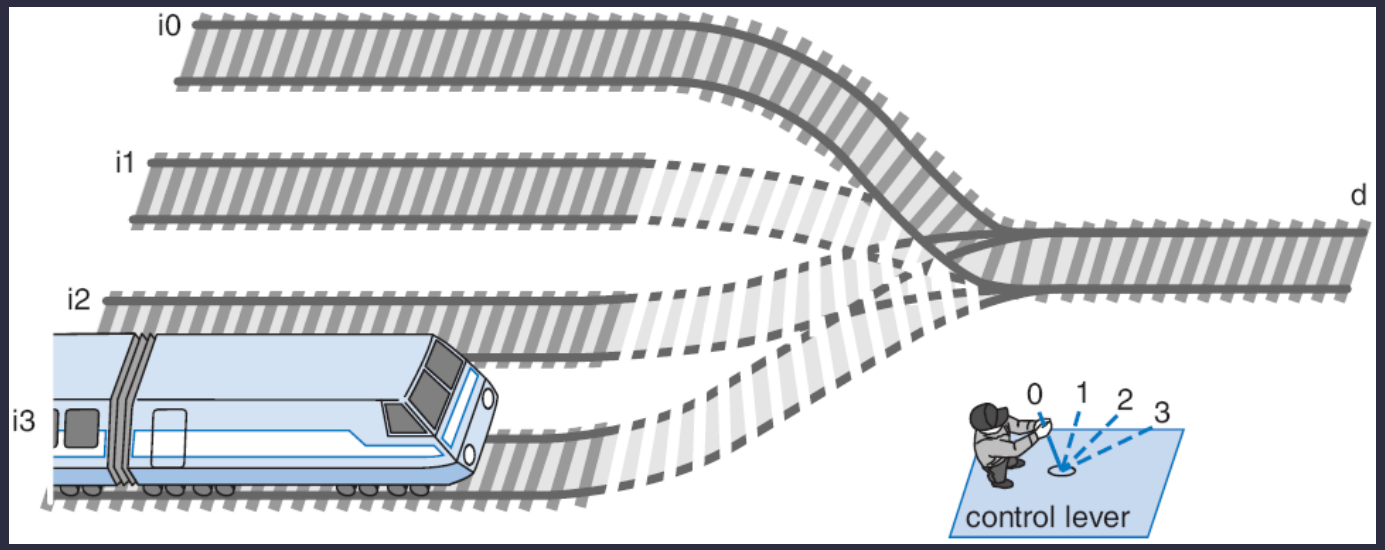




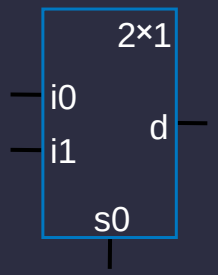


Multiplex e r (Mux)

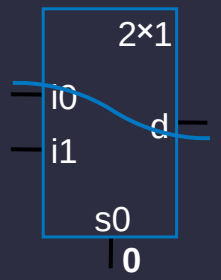
- Mux: It is a combinational circuit. Outputs incoming inputs according to the select bit.
  - 4 input mux → 2 select inputs
  - 8 input mux → 3 select input
  - N inputs → $\log_2(N)$ select input

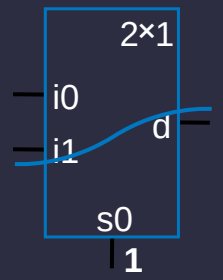


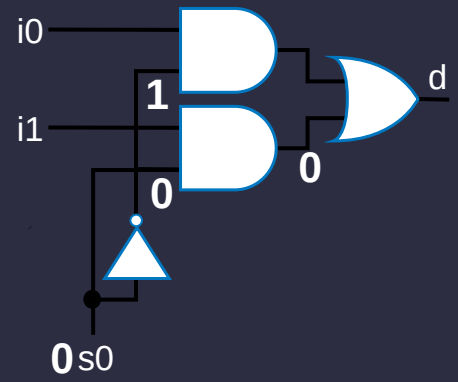
Mux Internal Structure

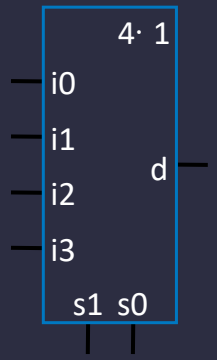


2x1 mux

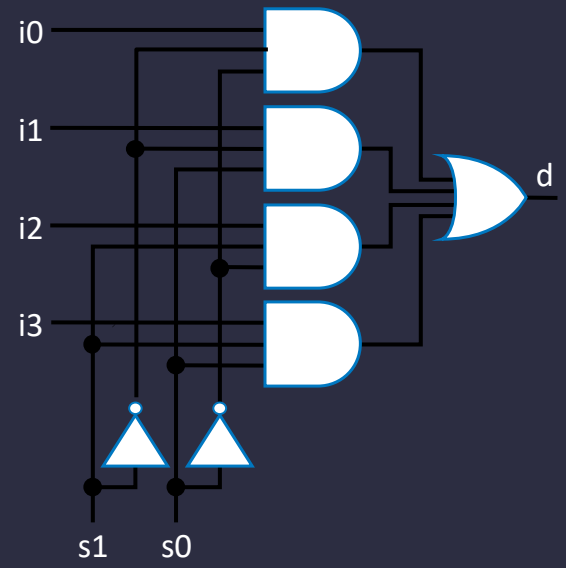




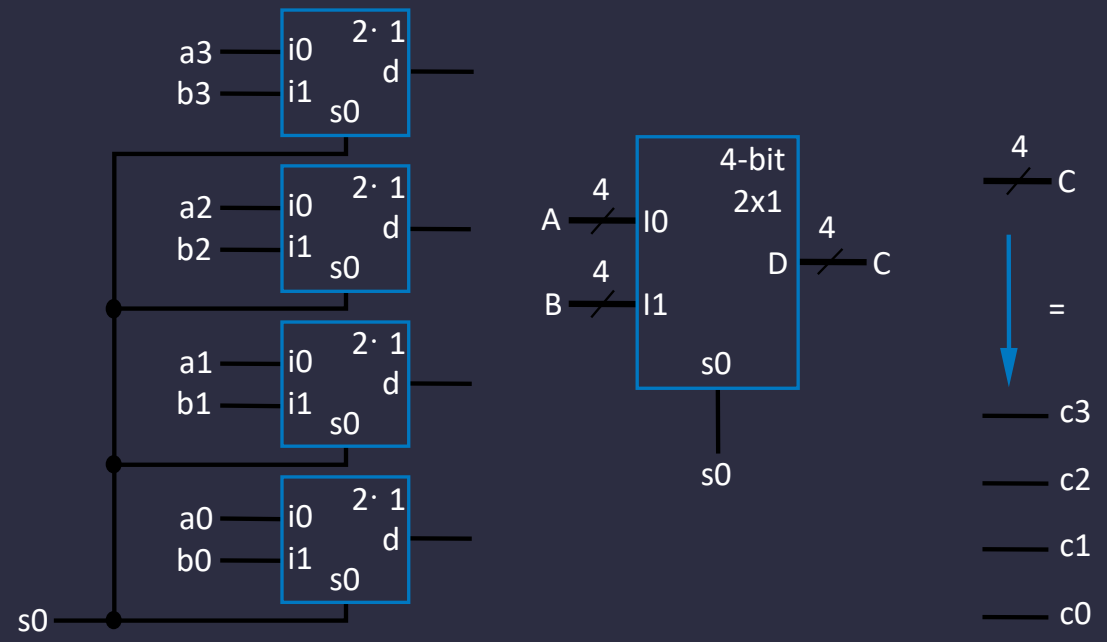




4x1 mux

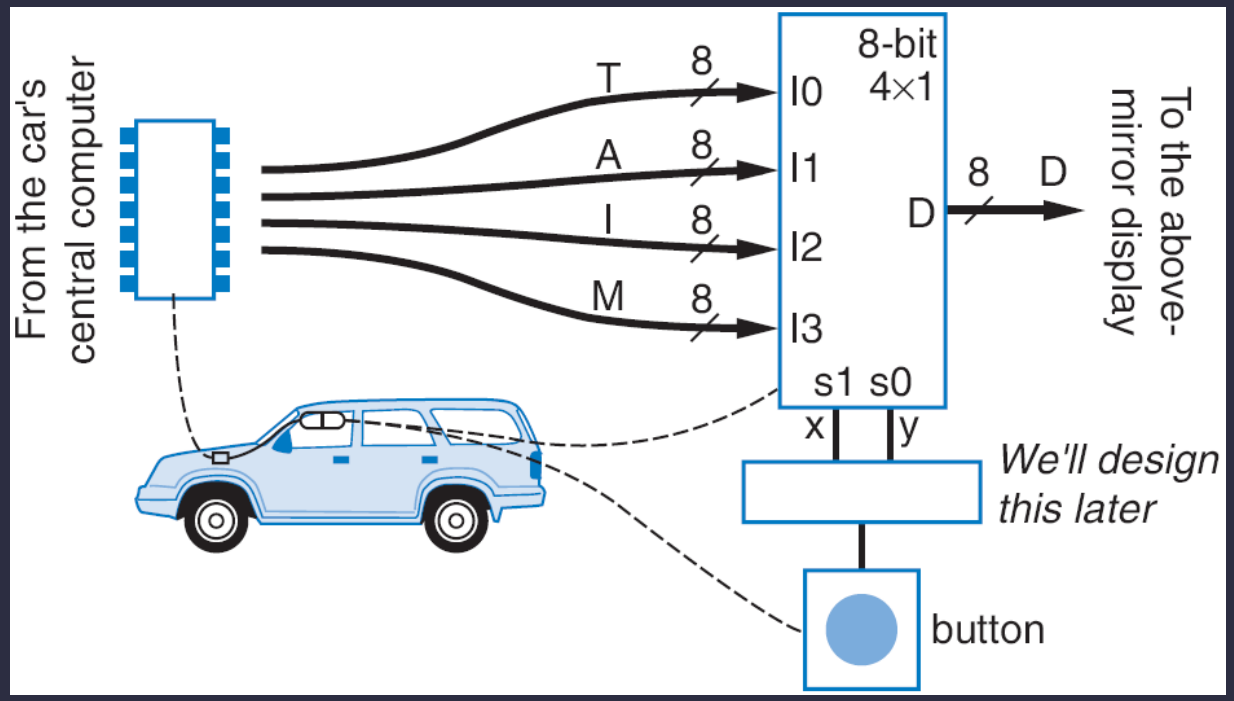


MUX Merge



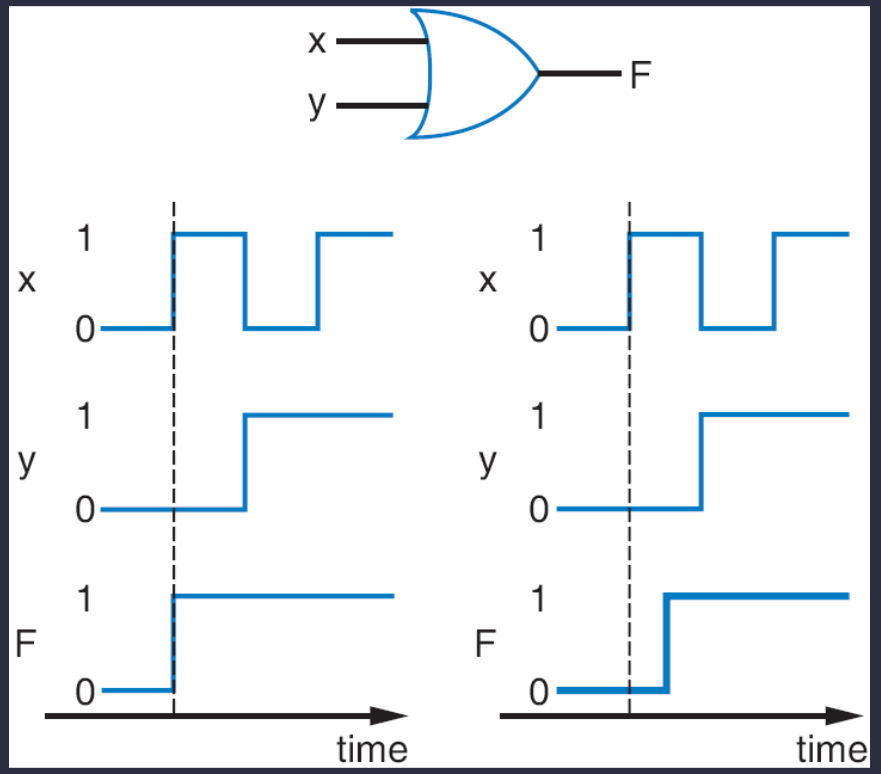
- Example : Two 4-bit inputs , A (a3 a2 a1 a0) and B (b3 b2 b1 b0)
  - 4-bit 2x1 MUX can be done using 4 1 bit, 2x1 MUX

N-bit MUX Example



- There are 4 possible texts to display
  - Temperature , Average Fuel Usage , Average Speed , KM Remaining - all
  - Which one will appear on the screen is selected with the x and y bits.
  - 8-bit 4x1 MUX can be used.

Door Delays



- All circuits have a delay.
  - Outputs don't change instantly