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Department of Electrical Engineering



Digital Design

First Semester 2020-21

Tutorial : 05

Combinational Circuit Design

Digital Design Tutorial : 05

1.

A committee of three individuals decide issues for an organization. Each individual votes either yes or no for each proposal that arises. A proposal is passed if it receives at least two yes votes. Design a circuit that determines whether a proposal passes.

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1.

Inputs are three (x, y, z), Output is proposal (F)

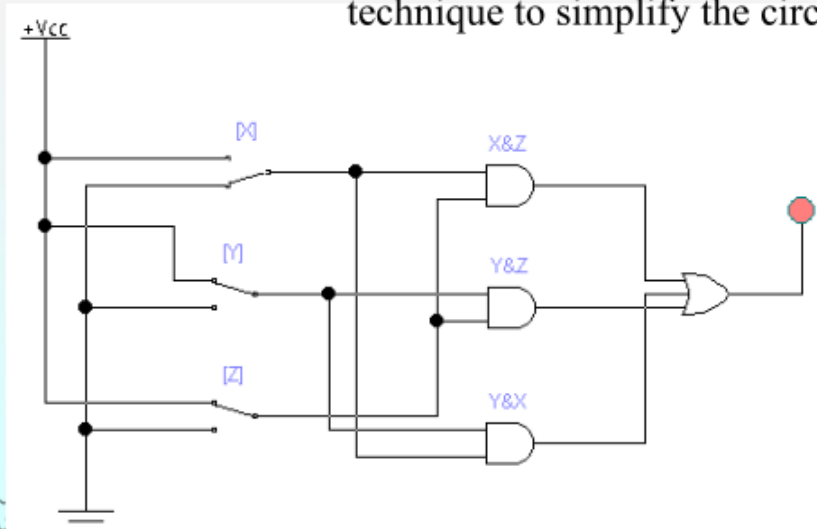
Individual1 (X)	Individual2 (Y)	Individual3 (Z)	Proposal(F)
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	1

X \ YZ	00	01	11	10
0			1	
1		1	1	1

$$F = XY + XZ + YZ$$

We used K-Map minimization technique to simplify the circuit.

We used truth table to make a relationship between inputs and output.



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2. Design a Two bit Magnitude Comparator

INPUT				OUTPUT		
A1	A0	B1	B0	A<B	A=B	A>B
0	0	0	0	0	1	0
0	0	0	1	1	0	0
0	0	1	0	1	0	0
0	0	1	1	1	0	0
0	1	0	0	0	0	1
0	1	0	1	0	1	0
0	1	1	0	1	0	0
0	1	1	1	1	0	0
1	0	0	0	0	0	1
1	0	0	1	0	0	1
1	0	1	0	0	1	0
1	0	1	1	1	0	0
1	1	0	0	0	0	1
1	1	0	1	0	0	1
1	1	1	0	0	0	1
1	1	1	1	0	0	1
1	1	1	1	0	1	0

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2. Design a Two bit Magnitude Comparator

$A > B$

B_1B_0	00	01	11	10	
A_1A_0	00	0	0	0	0
01	1	0	0	0	
11	1	1	0	1	
00	1	1	0	0	

$$A > B: A_1B_1' + A_0B_1'B_0' + A_1A_0B_0'$$

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2. Design a Two bit Magnitude Comparator

		A = B			
		B1B0	00	01	11
A1A0	00	1	0	0	0
	01	0	1	0	0
	11	0	0	1	0
	00	0	0	0	1

$$\begin{aligned}
 A=B &: A1'A0'B1'B0' + A1'A0B1'B0 + A1A0B1B0 + A1A0'B1B0' \\
 &: A1'B1' (A0'B0' + A0B0) + A1B1 (A0B0 + A0'B0') \\
 &: (A0B0 + A0'B0') (A1B1 + A1'B1') \\
 &: (A0 \text{ Ex-Nor } B0) (A1 \text{ Ex-Nor } B1)
 \end{aligned}$$

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2. Design a Two bit Magnitude Comparator

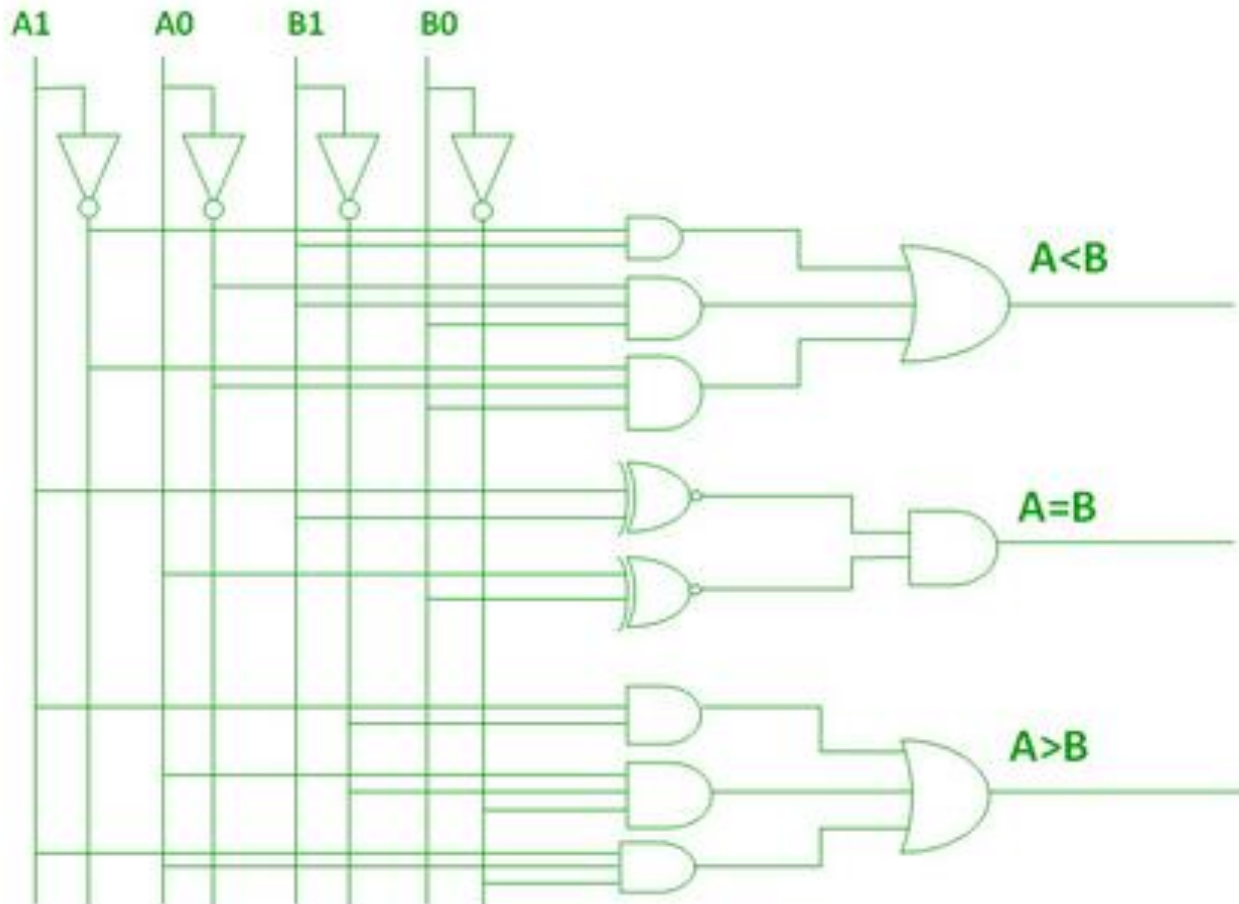
$A < B$

		B_1B_0			
		00	01	11	10
A_1A_0	00	0	1	1	1
	01	0	0	1	1
	11	0	0	0	0
	00	0	0	1	0

$$A < B : A_1' B_1 + A_0' B_1 B_0 + A_1' A_0' B_0$$

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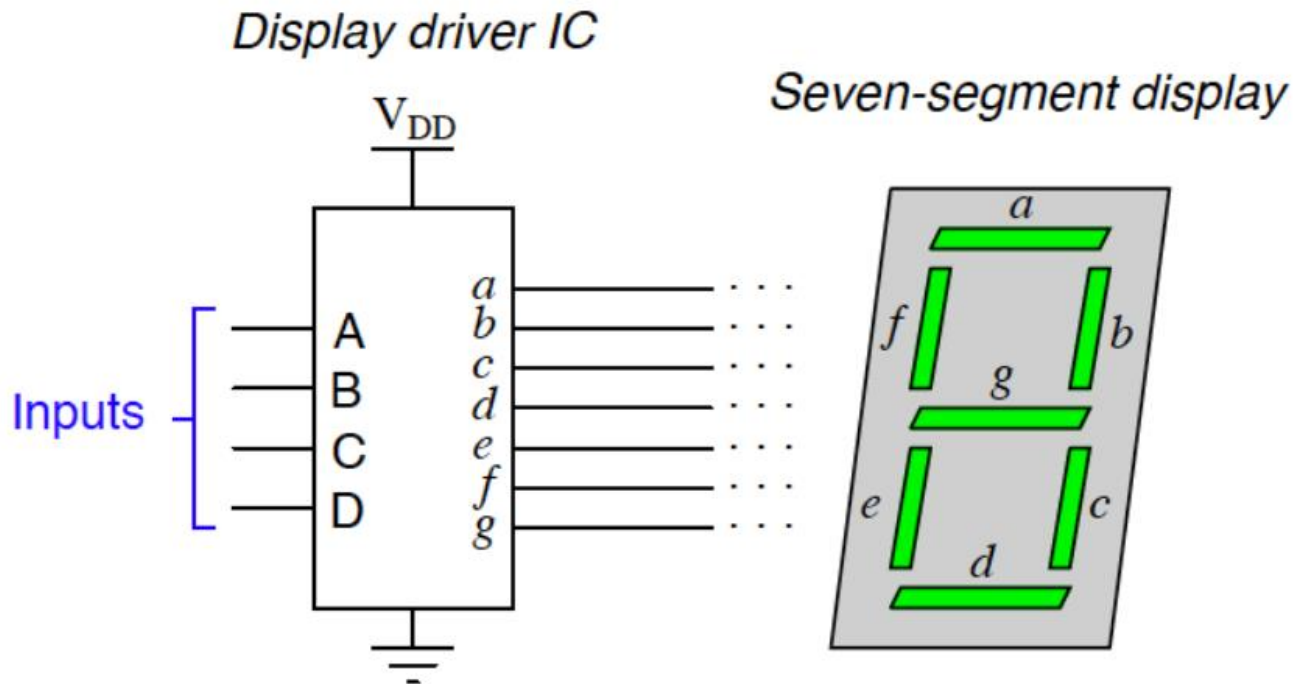
2. Design a Two bit Magnitude Comparator



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3. Design a 7-segment Decoder

Inputs A,B,C, D $(0-9)_{10}$ valid inputs & $(10-15)_{10}$ Don't Care
Outputs a,b,c,d,e,f



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3. Design a 7-segment Decoder

Inputs A,B,C, D $(0-9)_{10}$ valid inputs & $(10-15)_{10}$ Don't Care
Outputs a,b,c,d,e,f

D	C	B	A	a	b	c	d	e	f	g	Display
0	0	0	0	1	1	1	1	1	1	0	"0"
0	0	0	1	0	1	1	0	0	0	0	"1"
0	0	1	0	1	1	0	1	1	0	1	"2"
0	0	1	1	1	1	1	1	0	0	1	"3"
0	1	0	0	0	1	1	0	0	1	1	"4"
0	1	0	1	1	0	1	1	0	1	1	"5"
0	1	1	0	1	0	1	1	1	1	1	"6"
0	1	1	1	1	1	1	0	0	0	0	"7"
1	0	0	0	1	1	1	1	1	1	1	"8"
1	0	0	1	1	1	1	1	0	1	1	"9"

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3. Design a 7-segment Decoder

AB \ CD	00	01	11	10
00	1	0	1	1
01	0	1	1	1
11	x	x	x	x
10	1	1	x	x

$$a = A + C + BD + \overline{BD}$$

AB \ CD	00	01	11	10
00	1	0	1	1
01	1	0	1	0
11	x	x	x	x
10	1	1	x	x

$$b = \overline{B} + \overline{C} \overline{D} + CD$$

AB \ CD	00	01	11	10
00	1	1	1	0
01	1	1	1	1
11	x	x	x	x
10	1	1	x	x

$$c = B + \overline{C} + D$$

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3. Design a 7-segment Decoder

AB \ CD	00	01	11	10
00	1	0	1	1
01	0	1	0	1
11	x	x	x	x
10	1	1	x	x

$$d = \overline{B}\overline{D} + C\overline{D} + B\overline{C}D + \overline{B}C + A$$

AB \ CD	00	01	11	10
00	1	0	0	1
01	0	0	0	1
11	x	x	x	x
10	1	0	x	x

$$e = \overline{B}\overline{D} + C\overline{D}$$

AB \ CD	00	01	11	10
00	1	0	0	0
01	1	1	0	1
11	x	x	x	x
10	1	1	x	x

$$f = A + \overline{C}\overline{D} + B\overline{C} + B\overline{D}$$

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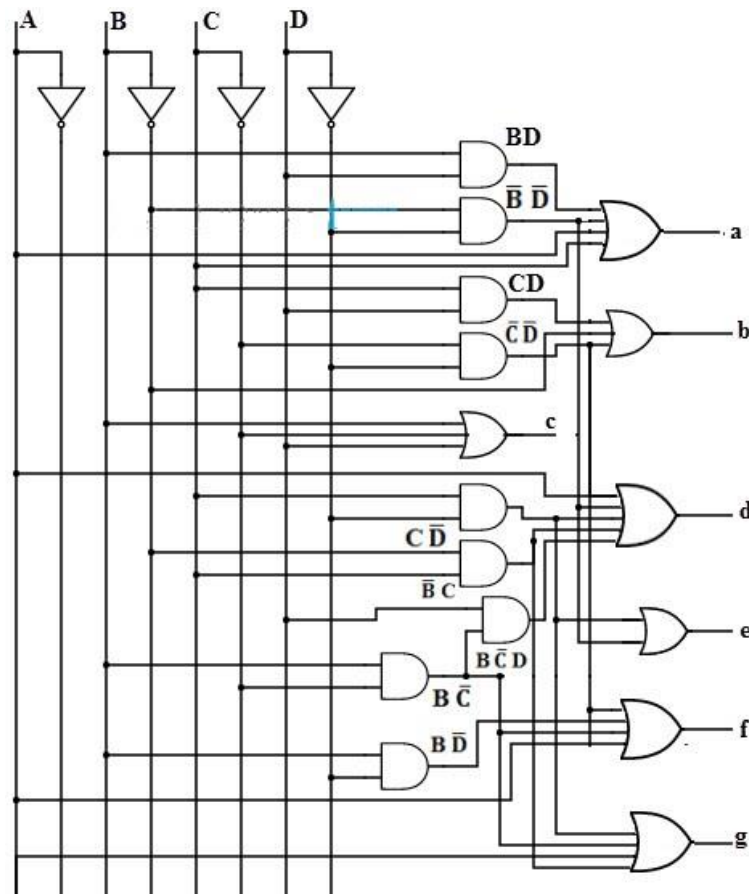
3. Design a 7-segment Decoder

AB \ CD	00	01	11	10
00	0	0	1	1
01	1	1	0	1
11	x	x	x	x
10	1	1	x	x

$$g = \bar{B}C + C\bar{D} + B\bar{C} + B\bar{C} + A$$

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3. Design a 7-segment Decoder

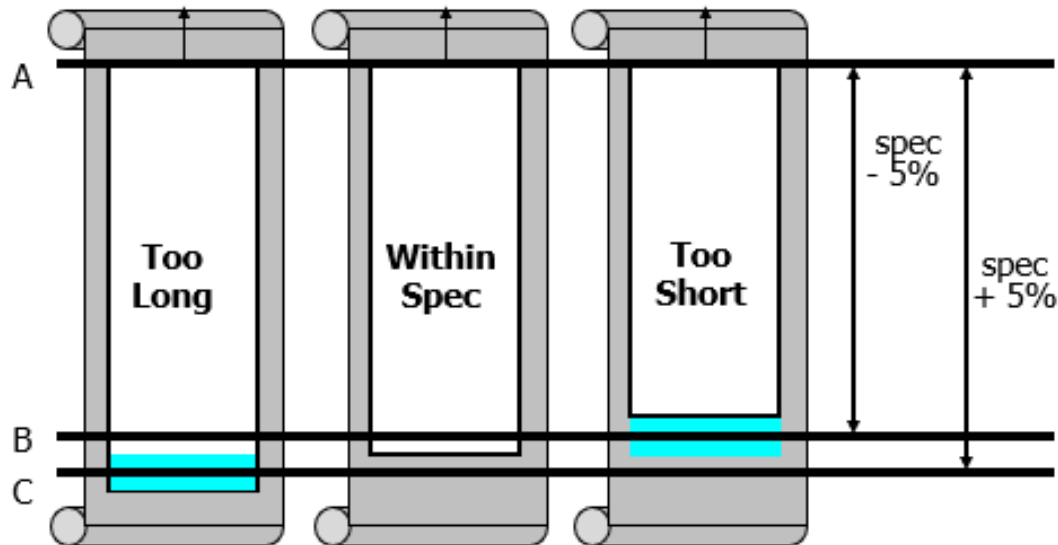


4. Production Line Control

- Rods of varying length ($\pm 10\%$) travel on conveyor belt
 - Mechanical arm pushes rods within spec ($\pm 5\%$) to one side
 - Second arm pushes rods too long to other side
 - Rods that are too short stay on belt
 - 3 light barriers (light source + photocell) as sensors
 - Design combinational logic to activate the arms
- Understanding the problem
 - Inputs are three sensors
 - Outputs are two arm control signals
 - Assume sensor reads "1" when tripped, "0" otherwise
 - Call sensors A, B, C

4. Production Line Control

- Position of Sensors
 - A to B distance = specification - 5%
 - A to C distance = specification + 5%



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4. Production Line Control

- Truth Table
 - Show don't cares

A	B	C	Function
0	0	0	do nothing
0	0	1	do nothing
0	1	0	do nothing
0	1	1	do nothing
1	0	0	too short
1	0	1	don't care
1	1	0	in spec
1	1	1	too long

logic implementation now straightforward
just use three 3-input AND gates

"too short" = $AB'C'$
(only first sensor tripped)

"in spec" = $A B C'$
(first two sensors tripped)

"too long" = $A B C$
(all three sensors tripped)