

NEC 304

STLD

Lecture 13
Combinational Design Procedure

Rajeev Pandey

Department Of ECE

rajeevvce2007@gmail.com

Overview

- **Design digital circuit from specification**
- **Digital inputs and outputs known**
 - Need to determine logic that can *transform* data
- **Start in truth table form**
- **Create K-map for each output based on function of inputs**
- **Determine minimized sum-of-product representation**
- **Draw circuit diagram**

Design Procedure (Mano)

Design a circuit from a specification.

1. Determine number of required inputs and outputs.
2. Derive truth table
3. Obtain simplified Boolean functions
4. Draw logic diagram and verify correctness

$$S = A + B + C$$
$$R = ABC$$

A	B	C	R	S
0	0	0	0	0
0	0	1	0	1
0	1	0	0	1
0	1	1	0	1
1	0	0	0	1
1	0	1	0	1
1	1	0	0	1
1	1	1	1	1

Previously, we have learned...

- **Boolean algebra can be used to simplify expressions, but not obvious:**
 - how to proceed at each step, or
 - if solution reached is minimal.
- **Have seen five ways to represent a function:**
 - Boolean expression
 - truth table
 - logic circuit
 - minterms/maxterms
 - Karnaugh map

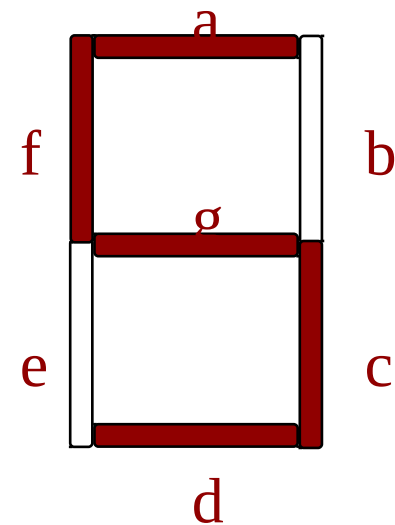
Combinational logic design

- **Use multiple representations of logic functions**
- **Use graphical representation to assist in simplification of function.**
- **Use concept of “don’t care” conditions.**
- **Example - encoding BCD to seven segment display.**
- **Similar to approach used by designers in the field.**

BCD to Seven Segment Display

- Used to display binary coded decimal (BCD) numbers using seven illuminated segments.
- BCD uses 0's and 1's to represent decimal digits 0 - 9. Need four bits to represent required 10 digits.
- Binary coded decimal (BCD) represents each decimal digit with four bits

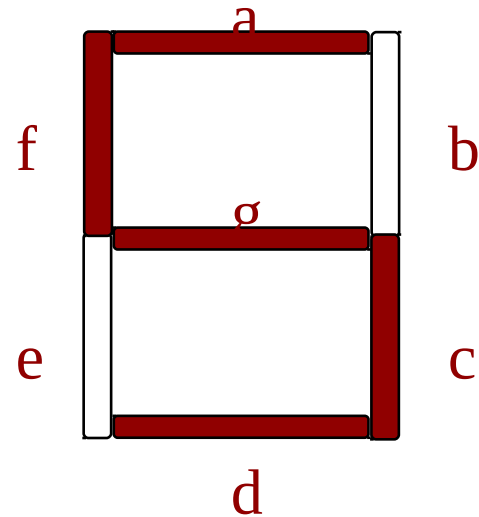
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	1	0
5	0	1	0	0
6	0	1	0	1
7	1	0	0	0
8	1	0	0	1
9	1	1	0	0



BCD to seven segment display

- ° List the segments that should be illuminated for each digit.

0	a,b,c,d,e,f
1	b,c
2	a,b,d,e,g
3	a,b,c,d,g
4	b,c,f,g
5	a,c,d,f,g
6	a,c,d,e,f,g
7	a,b,c
8	a,b,c,d,e,f,g
9	a,b,c,d,f,g



BCD to seven segment display

- ° Derive the truth table for the circuit.
- ° Each output column in one circuit.

	Inputs				Outputs					
Dec	w	x	y	z	a	b	c	d	e	.
0	0	0	0	0	1	1	1	1	1	.
1	0	0	0	1	0	1	1	0	0	.
2	0	0	1	0	1	1	0	1	1	.
.
7	0	1	1	1	1	1	1	0	0	.
8	1	0	0	0	1	1	1	1	1	.
9	1	0	0	1	1	1	1	1	0	.

BCD to seven segment display

- Find minimal sum-of-products representation for each **output**

For segment “a” :

		yz			
		00	01	11	10
wx	00	1	0	1	1
	01	0	1	1	1
	11				
	10	1	1		

Note: Have only filled in ten squares, corresponding to the ten numerical digits we wish to represent.

Don't care conditions (BCD display) ...

- Fill in don't cares for **undefined** outputs.
 - Note that these combinations of inputs should never happen.
- Leads to a reduced implementation

For segment “a” :

		yz			
		00	01	11	10
wx	00	1	0	1	1
	01	0	1	1	1
	11	X	X	X	X
	10	1	1	X	X

Put in “X” (don't care), and interpret as either 1 or 0 as desired

Don't care conditions (BCD display) ...

- Circle biggest group of 1's and Don't Cares.
- Leads to a reduced implementation

For segment “a” :

		yz			
		00	01	11	10
wx	00	1	0	1	1
	01	0	1	1	1
	11	X	X	X	X
	10	1	1	X	X

$$F_{a1} = y$$

Don't care conditions (BCD display)

- Circle biggest group of 1's and Don't Cares.
- Leads to a reduced implementation

For segment “a” :

wx \ yz	yz			
	00	01	11	10
00	1	0	1	1
01	0	1	1	1
11	X	X	X	X
10	1	1	X	X

$$F_{a2} = w$$

Don't care conditions (BCD display) ...

- Circle biggest group of 1's and Don't Cares.
- All 1's should be covered by at least one implicant

For segment “a” :

		yz			
		00	01	11	10
wx	00	1	0	1	1
	01	0	1	1	1
	11	X	X	X	X
	10	1	1	X	X

$$F_{a3} = \bar{x}\bar{z}$$

		yz			
		00	01	11	10
wx	00	1	0	1	1
	01	0	1	1	1
	11	X	X	X	X
	10	1	1	X	X

$$F_{a4} = xz$$

Don't care conditions (BCD display) ...

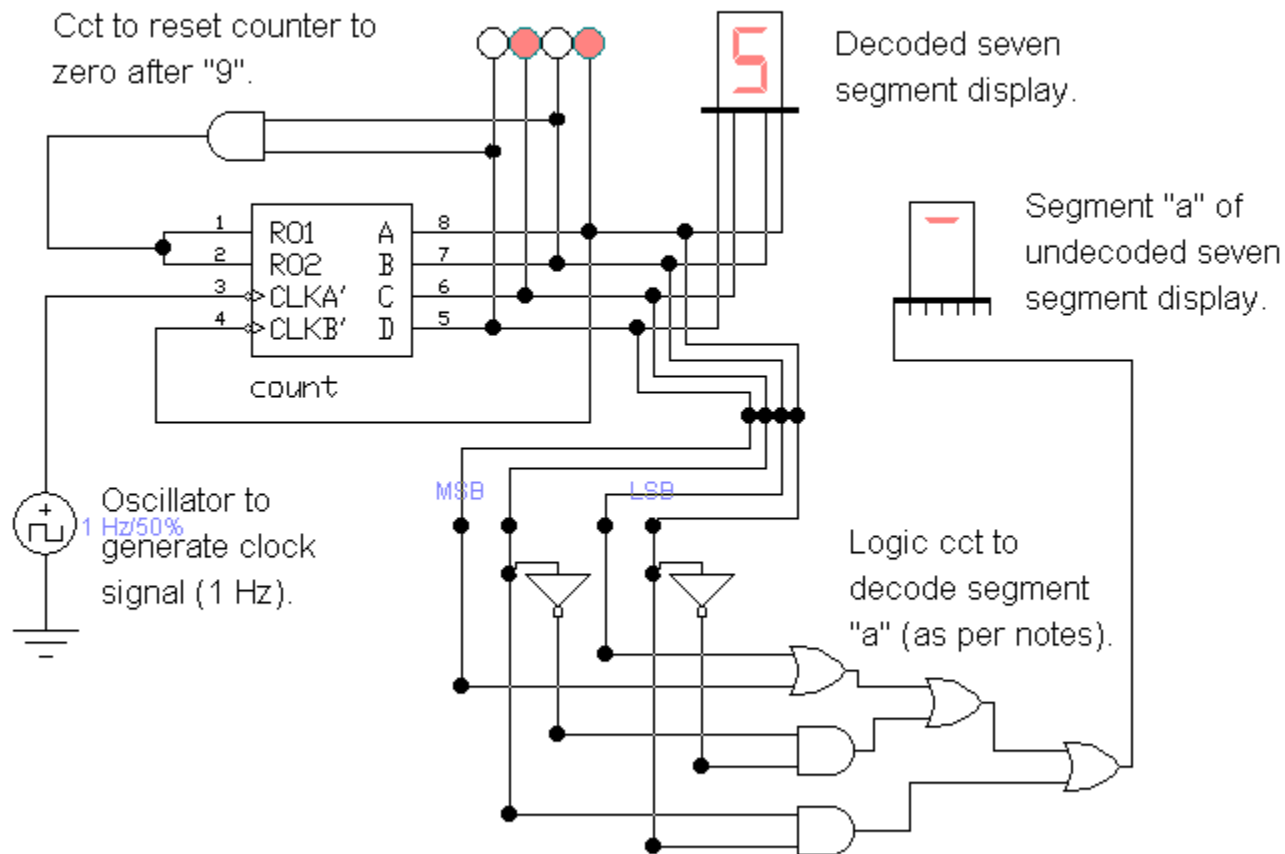
- Put all the terms together
- Generate the circuit

For segment “a” :

		yz			
		00	01	11	10
wx	00	1	0	1	1
	01	0	1	1	1
	11	X	X	X	X
	10	1	1	X	X

$$F = y + w + \bar{x} \bar{z} + xz$$

Example of seven segment display decoding.



Hint: Select a component and then push "?" from main menu bar to get info on what that component does and how it works.

BCD to seven segment display

- ° Derive the truth table for the circuit.
- ° Each output column in one circuit.

	Inputs				Outputs					
Dec	w	x	y	z	a	b	c	d	e	.
0	0	0	0	0	1	1	1	1	1	.
1	0	0	0	1	0	1	1	0	0	.
2	0	0	1	0	1	1	0	1	1	.
.
7	0	1	1	1	1	1	1	0	0	.
8	1	0	0	0	1	1	1	1	1	.
9	1	0	0	1	1	1	1	1	0	.

BCD to seven segment display

- Find minimal sum-of-products representation for each **output**

For segment “b” :

		yz			
		00	01	11	10
wx	00	1	1	1	1
	01	1	0	1	0
	11				
	10	1	1		

See if you
complete this
example.

Summary

- **Need to formulate circuits from problem descriptions**
 1. Determine number of inputs and outputs
 2. Determine truth table format
 3. Determine K-map
 4. Determine minimal SOP
- **There may be multiple outputs per design**
 - Solve each output separately
- **Current approach doesn't have memory.**
 - This will be covered next week.