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.

Digital Design Tutorial : 05

1.

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

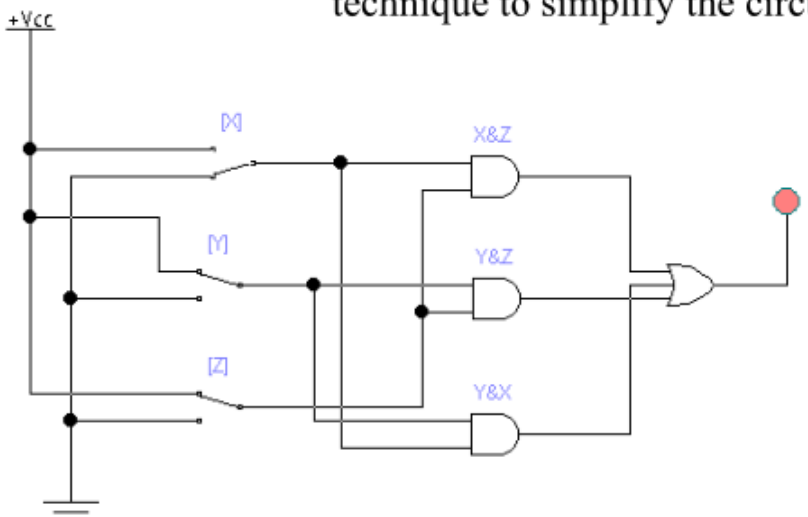
Individual1 (X)	Individual2 (Y)	Individual3 (Z)	Proposal(F)
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	1

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.



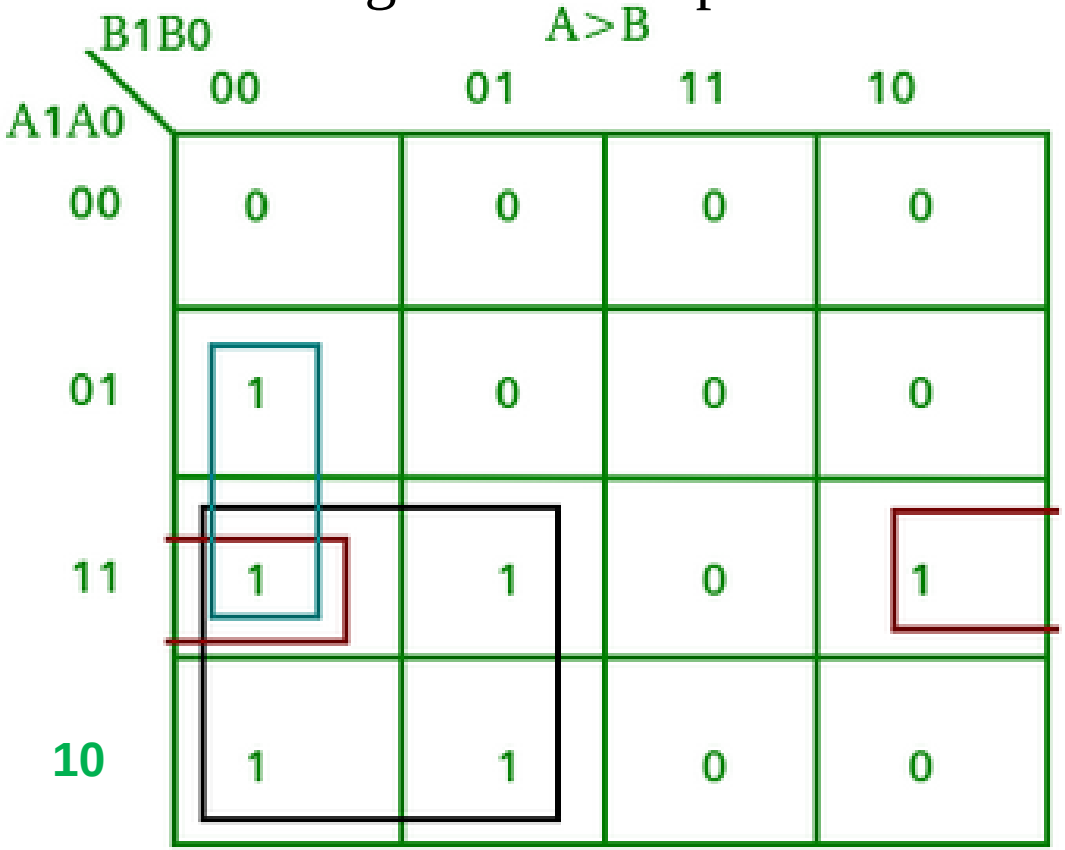
Digital Design Tutorial : 05

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	1	0

Digital Design Tutorial : 05

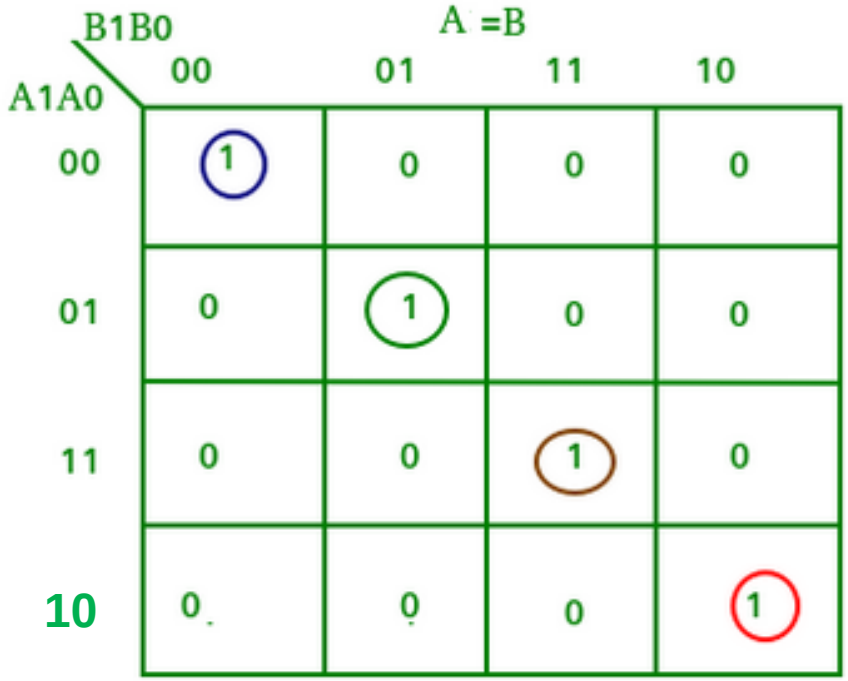
2. Design a Two bit Magnitude Comparator



A>B:A1B1’ + A0B1’B0’ + A1A0B0’

Digital Design Tutorial : 05

2. Design a Two bit Magnitude Comparator



A=B: A1'A0'B1'B0' + A1'A0B1'B0 + A1A0B1B0 + A1A0'B1B0'

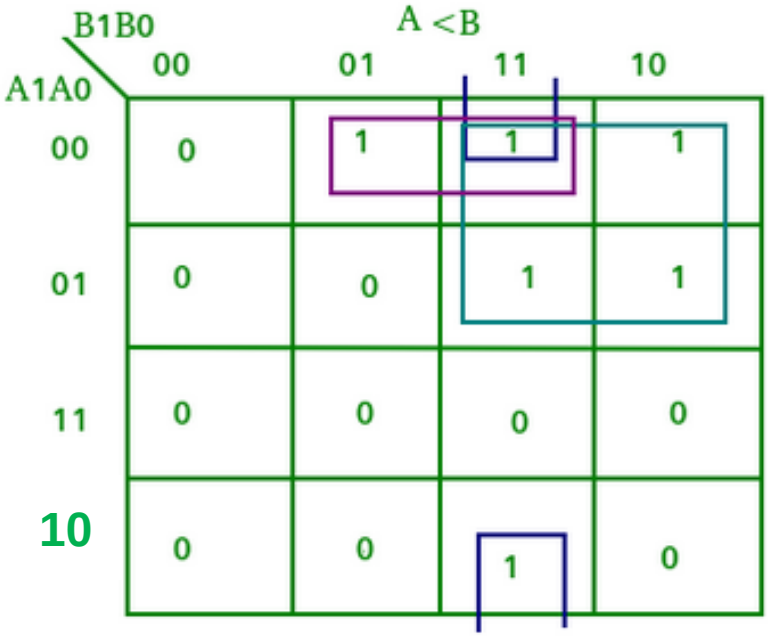
: A1'B1' (A0'B0' + A0B0) + A1B1 (A0B0 + A0'B0')

: (A0B0 + A0'B0') (A1B1 + A1'B1')

: (A0 Ex-Nor B0) (A1 Ex-Nor B1)

Digital Design Tutorial : 05

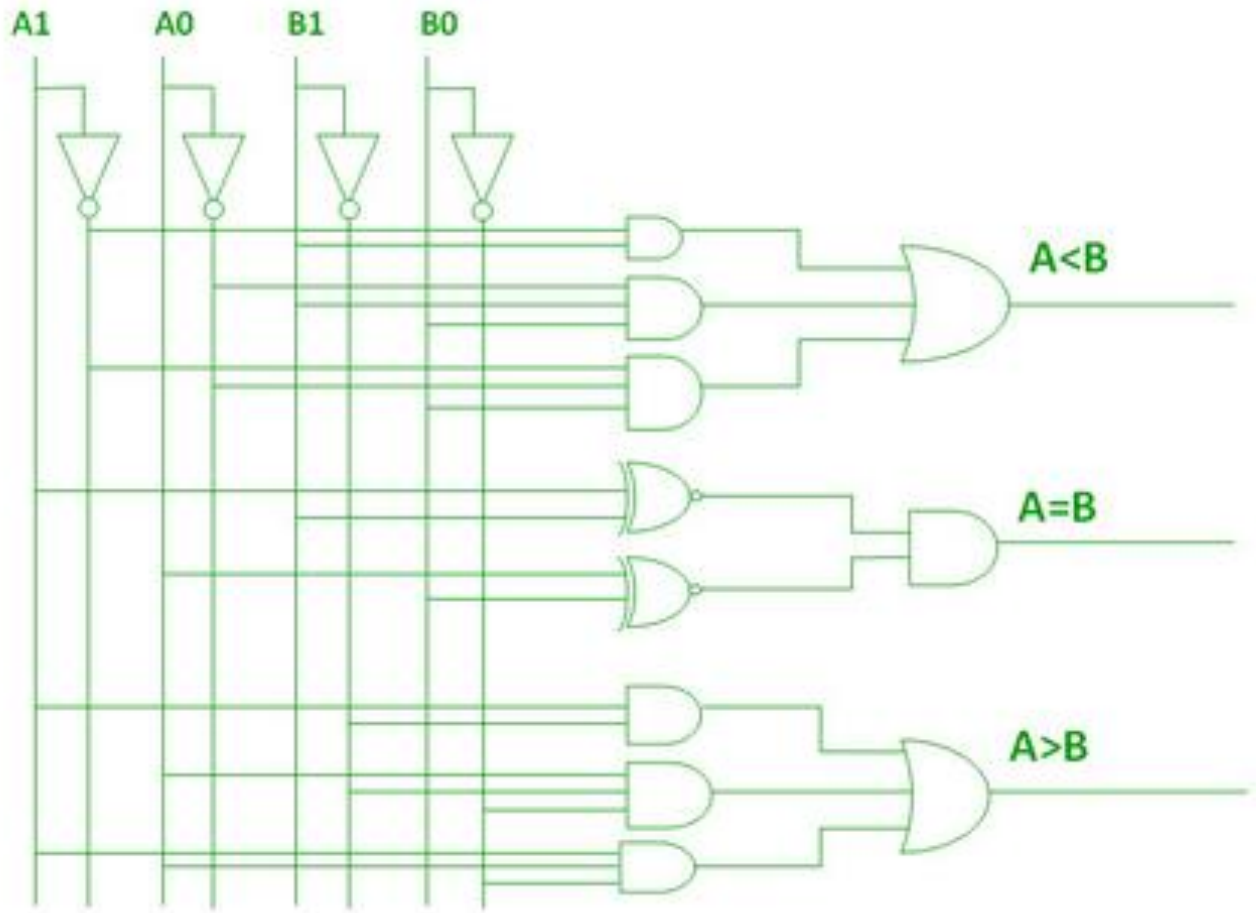
2. Design a Two bit Magnitude Comparator



$$A<B: A1'B1 + A0'B1B0 + A1'A0'B0$$

Digital Design Tutorial : 05

2. Design a Two bit Magnitude Comparator

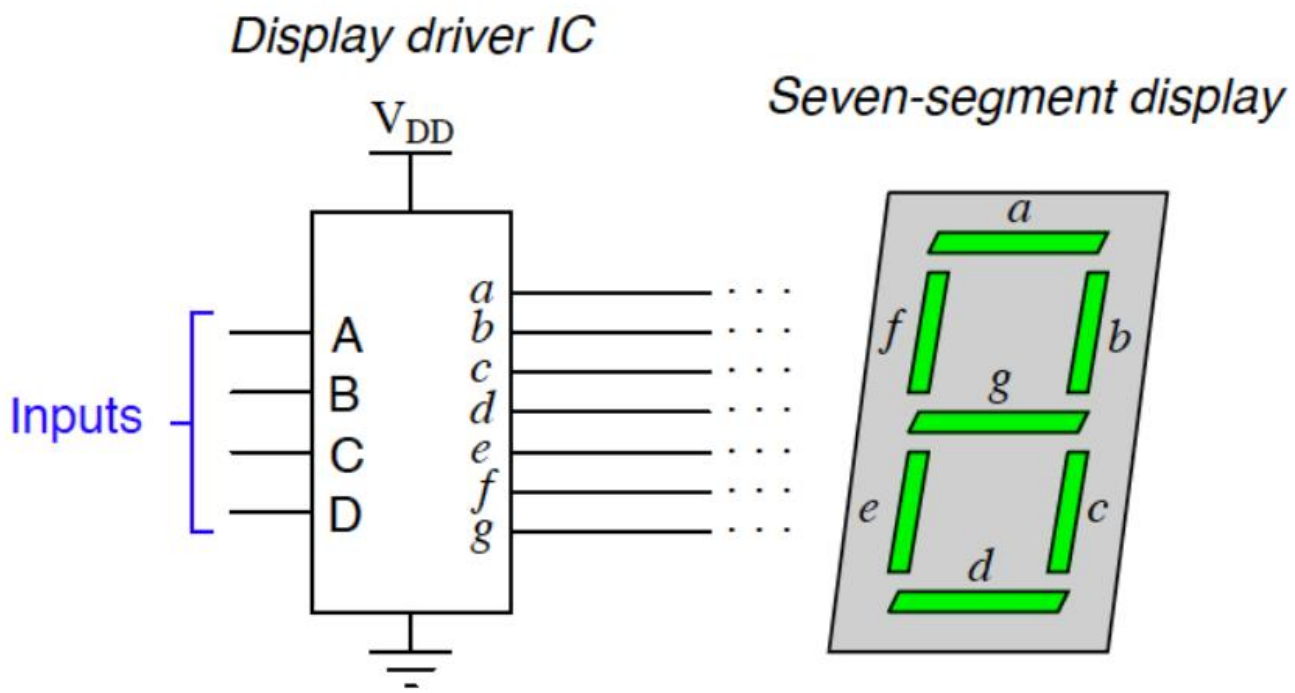


Digital Design Tutorial : 05

3. Design a 7-segment Decoder

   Inputs A,B,C, D $(0\text{-}9)_{10}$ valid inputs & $(10\text{-}15)_{10}$ Don't Care

   Outputs a,b,c,d,e,f



Digital Design Tutorial : 05

3. Design a 7-segment Decoder

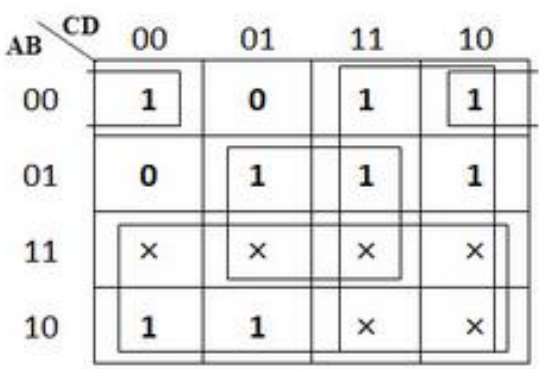
   Inputs A,B,C, D $(0\text{-}9)_{10}$ valid inputs & $(10\text{-}15)_{10}$ Don't Care

   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"

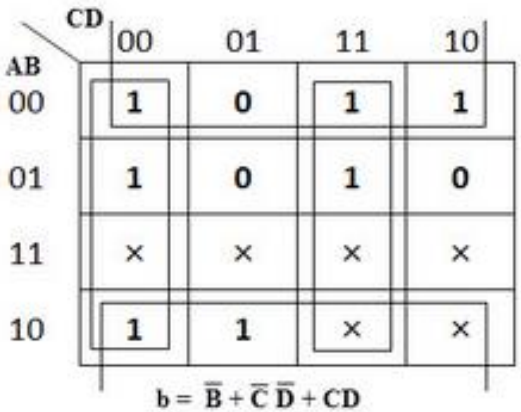
Digital Design Tutorial : 05

3. Design a 7-segment Decoder



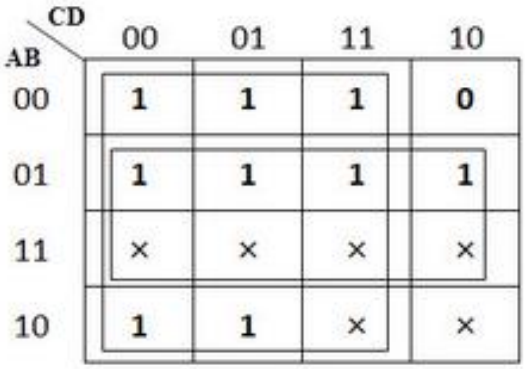
AB \ CD	00	01	11	10
00	1	0	1	1
01	0	1	1	1
11	×	×	×	×
10	1	1	×	×

$a = A + C + BD + \overline{B}\,\overline{D}$



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

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

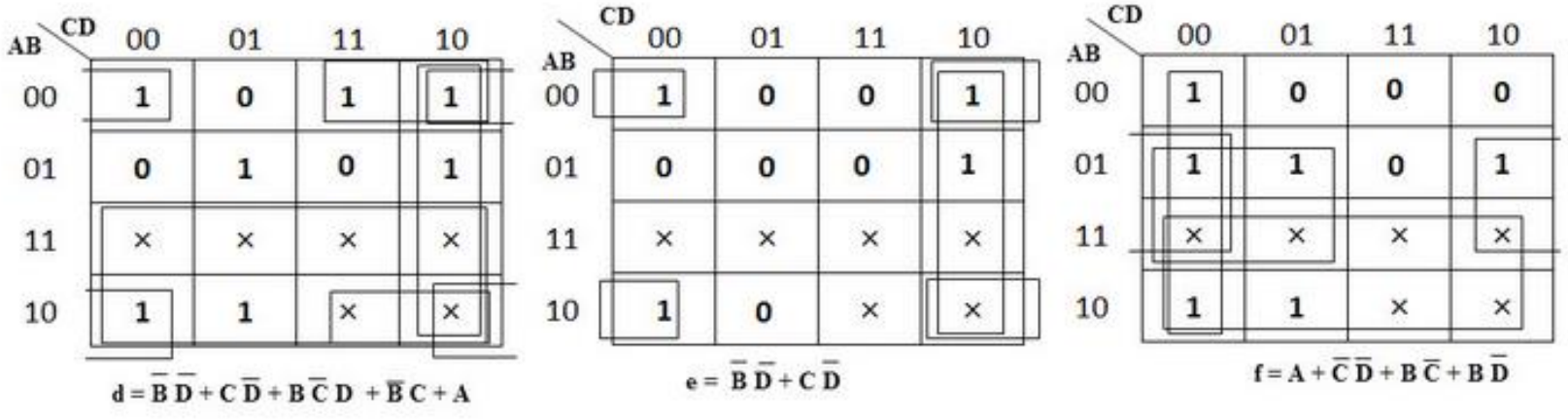


AB \ CD	00	01	11	10
00	1	1	1	0
01	1	1	1	1
11	×	×	×	×
10	1	1	×	×

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

Digital Design Tutorial : 05

3. Design a 7-segment Decoder



Digital Design Tutorial : 05

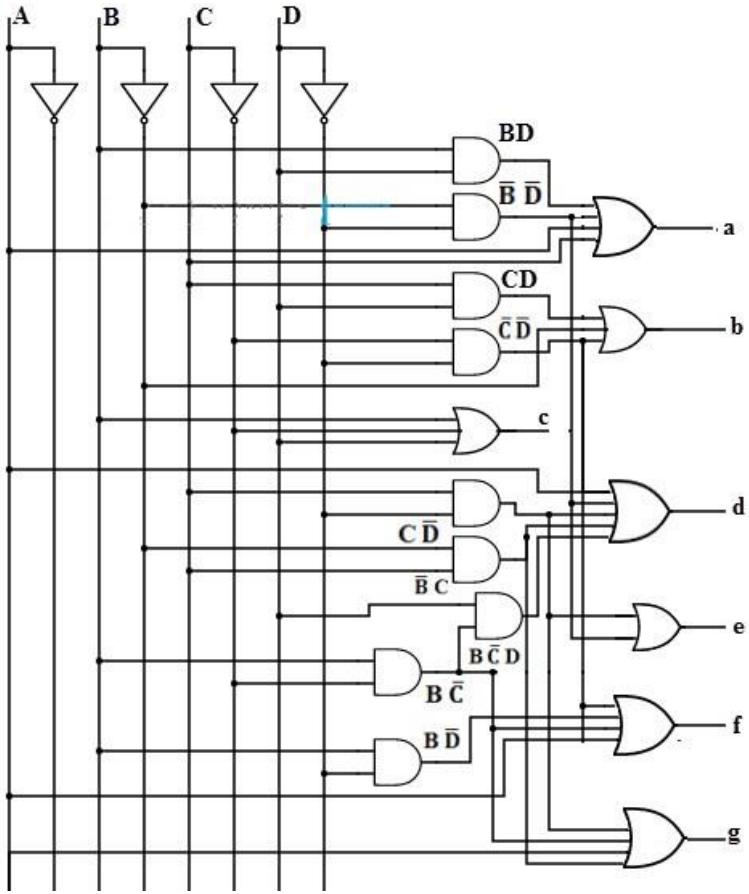
3. Design a 7-segment Decoder

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

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

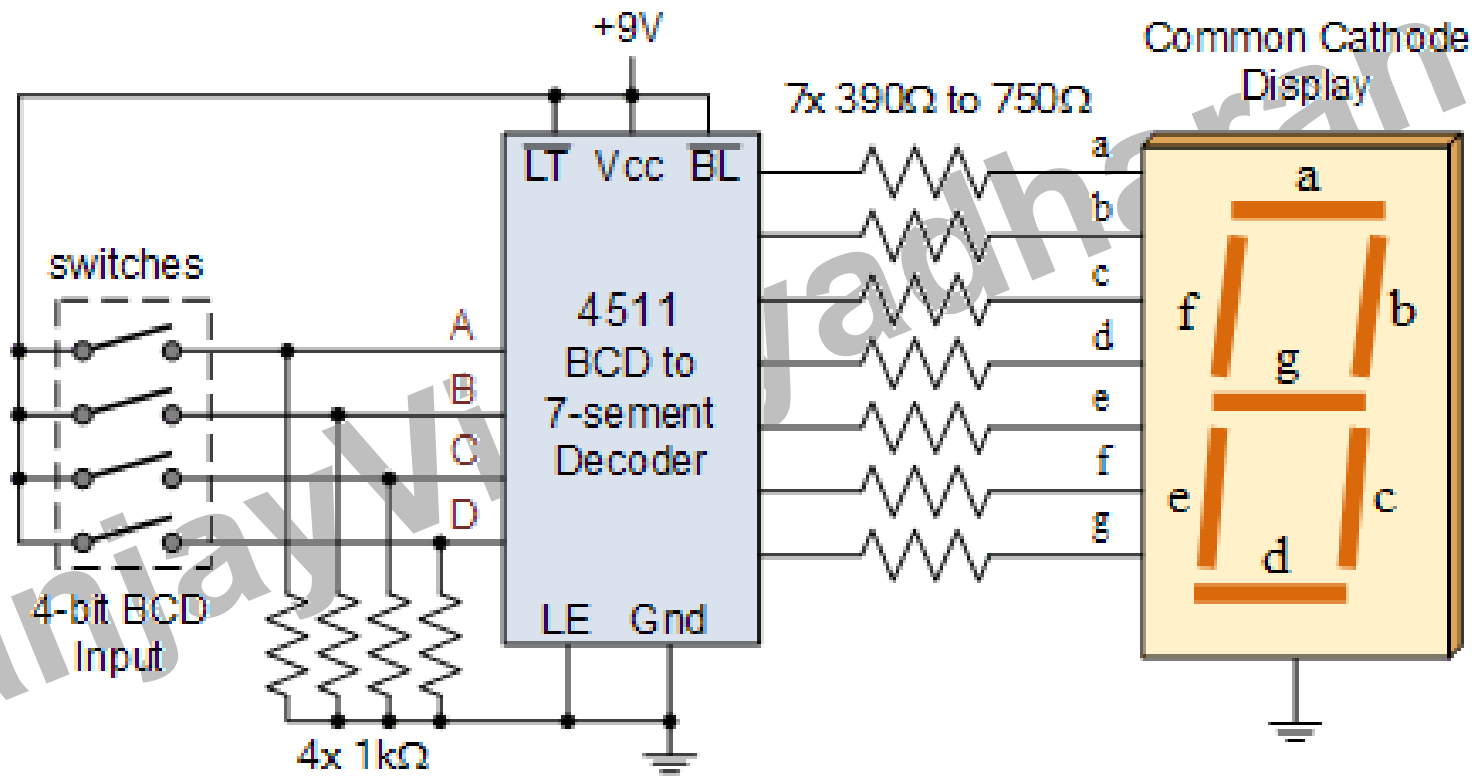
Digital Design Tutorial : 05

3. Design a 7-segment Decoder



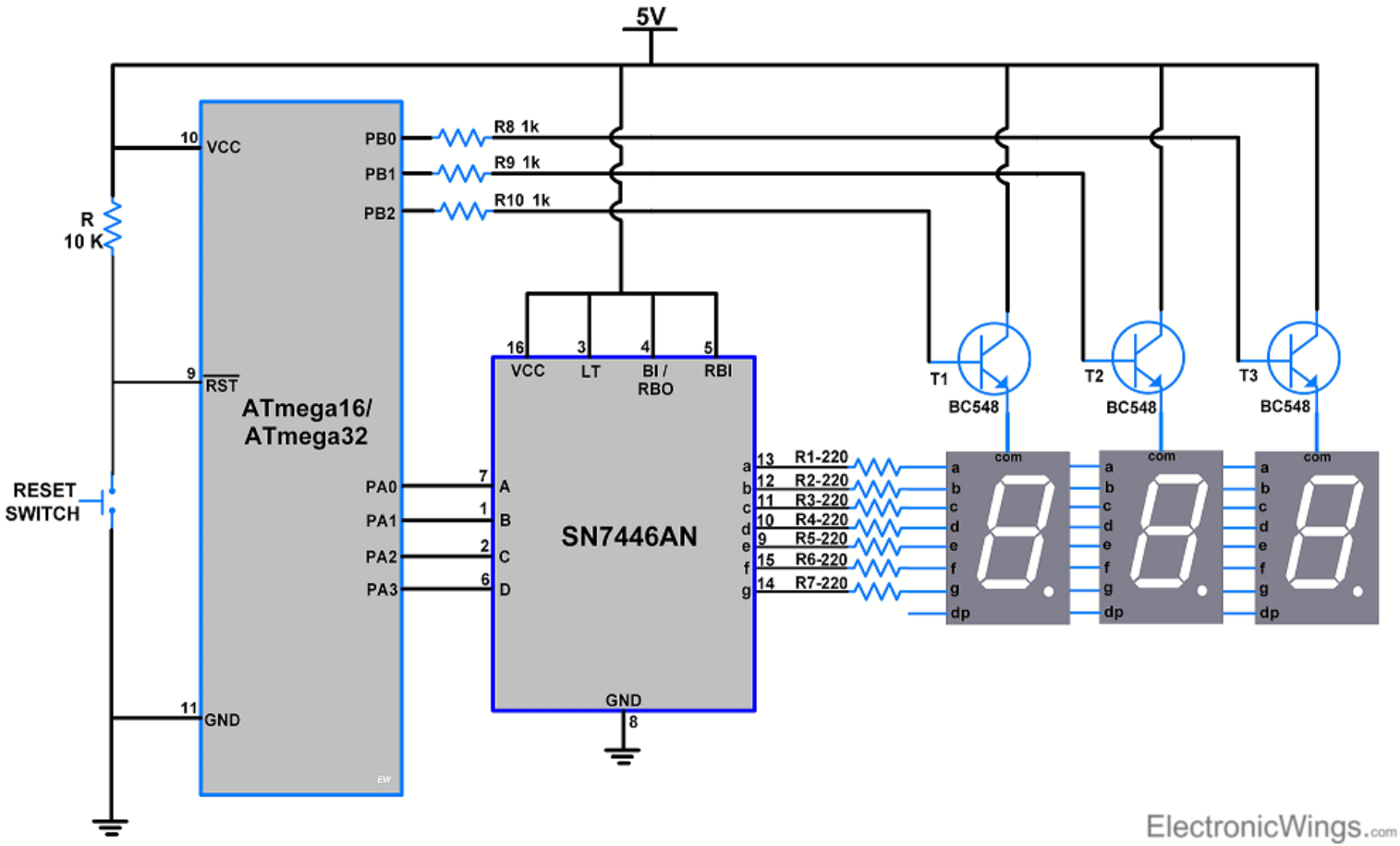
Digital Design Tutorial : 05

3. 7-segment Decoders



Digital Design Tutorial : 05

3. 7-segment Decoders



Digital Design Tutorial : 05

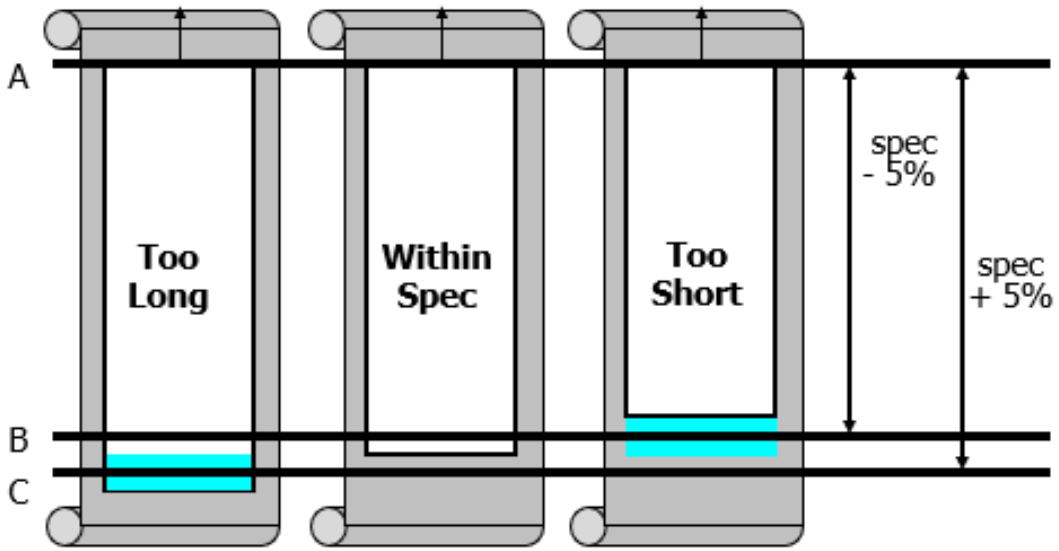
4. Production Line Control

- Rods of varying length (+/-10%) travel on conveyor belt
  - Mechanical arm pushes rods within spec (+/-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

Digital Design Tutorial : 05

4. Production Line Control

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



Digital Design Tutorial : 05

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)