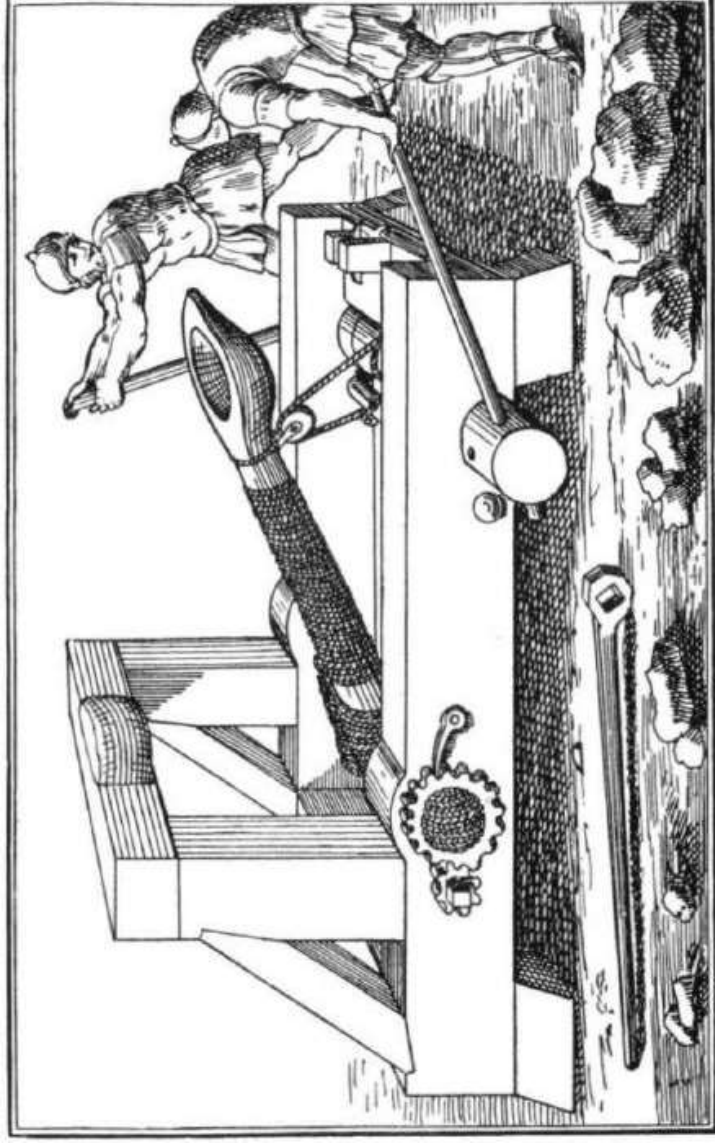


Engineering Design Project-I: Mangonel

- In Engineering Design Project-I, Mangonel (Roman catapult) is to be designed and implemented.



Mangonel: Electronics Part

The Electronic Part is divided into 4 sections:

- Programming of Arduino Digital I/O pins for various applications.
- Sensing any activity through Arduino and instructing accordingly.
Also, data capturing through sensors.
- Interfacing of hardware and software to do a specific task (using 7-segment display)
- Develop a micro-electronic circuit to determine and display the angular velocity of the throwing arm.



Mangonel: Electronics Part

The Electronic Part is divided into 4 sections:

- Programming of Arduino Digital I/O pins for various applications.
- Sensing any activity through Arduino and instructing accordingly.
Also, data capturing through sensors.
- Interfacing of hardware and software to do a specific task (using 7-segment display)
- Develop a micro-electronic circuit to determine and display the angular velocity of the throwing arm.



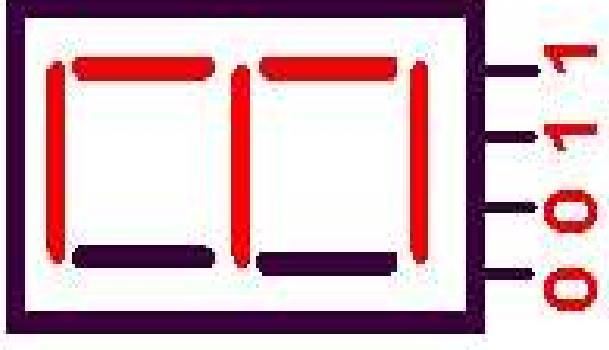
Contents

1. Binary Coded Decimal (BCD) Number
2. 7-segment Display
3. BCD Adder
4. Sketch



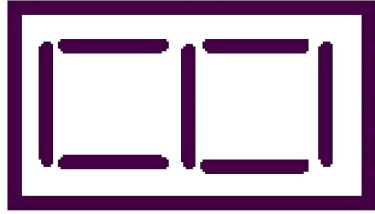
Introduction to BCD number

- Although binary data is the most efficient storage scheme; However, some applications may not be desirable to work with binary data.
- For instance, the internal components of digital clocks keep track of the time in binary. The binary value must be converted to decimal before it can be displayed.
- The most common format used to represent decimal data is called binary coded decimal, or BCD.



Binary Coded Decimal (BCD)

- In BCD representation, every decimal digital is represented by four binary bits.



TTTT Data Input Lines

<u>BCD</u>	<u>Decimal</u>
0000	0
0001	1
0010	2
0011	3
0100	4
0101	5
0110	6
0111	7
1000	8
1001	9

Decimal to Binary and BCD Conversion

DECIMAL TO BCD CONVERSION

25

$$\begin{array}{r} 2 \overline{) 25} \\ \underline{12} \\ 2 \overline{) 12} \\ \underline{6} \\ 2 \overline{) 6} \\ \underline{3} \\ 2 \overline{) 3} \\ \underline{1} \\ \overline{) 1} \\ \underline{1} \\ \end{array}$$

$$(25)_{10} \rightarrow 11001_2$$

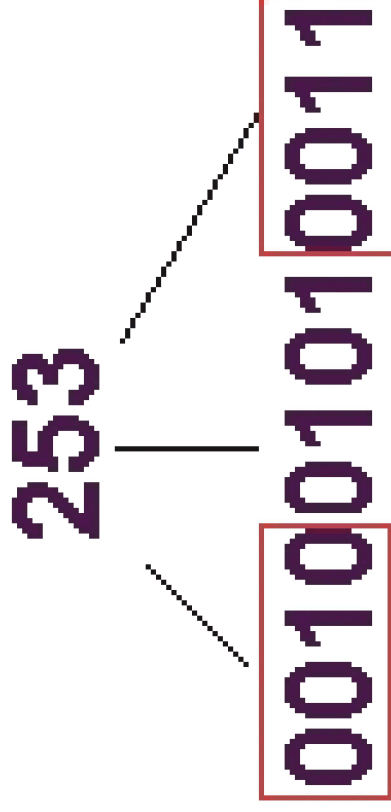
$$\begin{array}{c} \underline{2} \quad \underline{5} \\ \downarrow \quad \downarrow \\ 0010 \quad 0101 \end{array}$$

$$(25)_{10} \rightarrow (00100101)_{BCD}$$



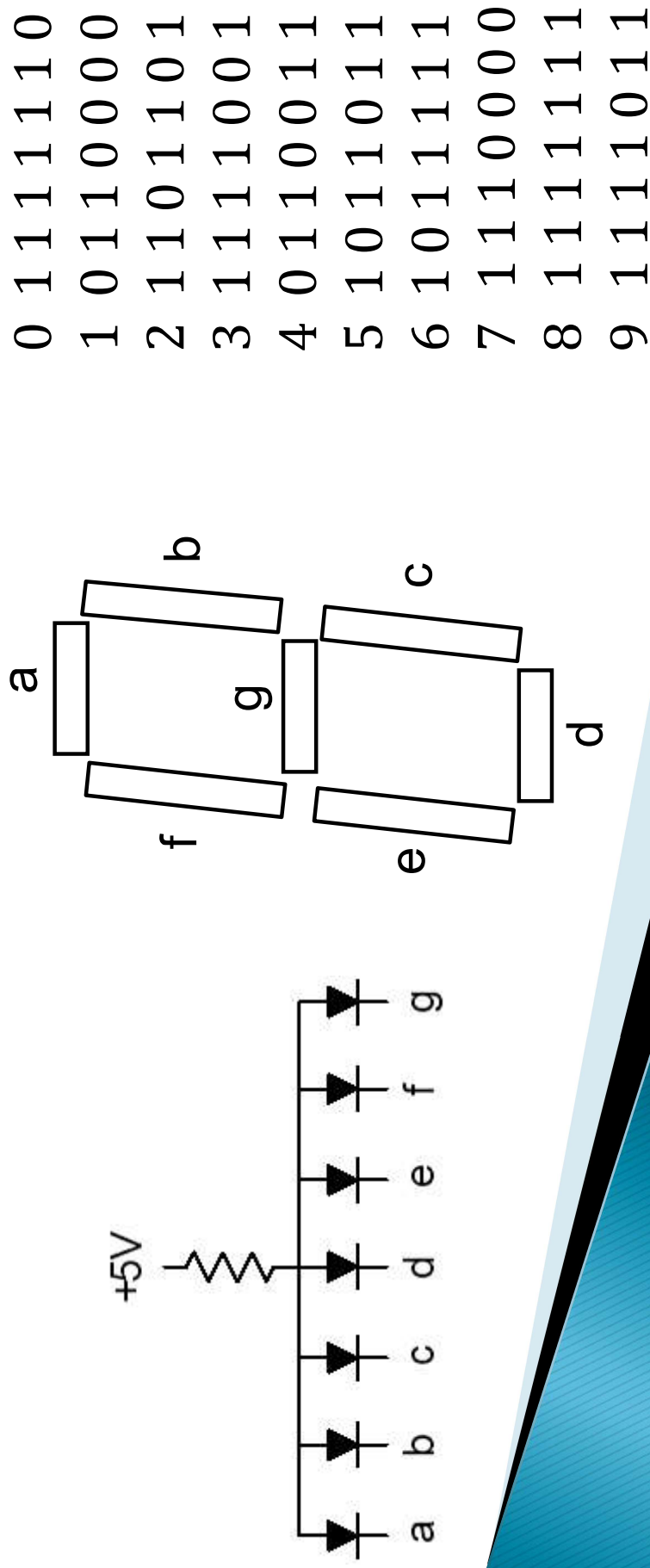
Multi-digit number to BCD

- Multi-digit decimal numbers are stored as multiple groups of 4 bits per digit.
- BCD is a **signed** notation
- Positive number: +27 as **0**(sign) 0010 0111.
- Negative number: -27 as **1**(sign) 0010 0111.
- **BCD does not store negative numbers in two's complement.**



Seven Segment Display

- Contains seven display units to form different numeric number.
- For example to represent number zero, LED a, b, c, d, e, and f must be turned ON (glowing) while g must be OFF.



Seven Segment Display

- Contains seven display units to form different numeric

A B C D	a	b	c	d	e	f	g
0 0 0 0	1	1	1	1	1	1	0
0 0 0 1	0	1	1	0	0	0	0
0 0 1 0	1	1	0	1	1	0	1
0 0 1 1	1	1	1	1	0	0	1
0 1 0 0	0	1	1	0	0	1	1
0 1 0 1	1	0	1	1	0	1	1
0 1 1 0	1	0	1	1	1	1	1
0 1 1 1	1	1	1	0	0	0	0
1 0 0 0	1	1	1	1	1	1	1
1 0 0 1	1	1	1	1	0	1	1

Seven Segment Display

- Contains seven display units to form different numeric

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

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

Seven Segment Display

- Contains seven display units to form different numeric

	00	01	11	10
00	1	0	1	1
01	1	0	1	0
11	x	x	x	x
10	1	1	x	x

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

Seven Segment Display

- Contains seven display units to form different numeric

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

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

Seven Segment Display

- Contains seven display units to form different numeric

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

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



Seven Segment Display

- Contains seven display units to form different numeric

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

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

Seven Segment Display

- Contains seven display units to form different numeric

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

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

Seven Segment Display

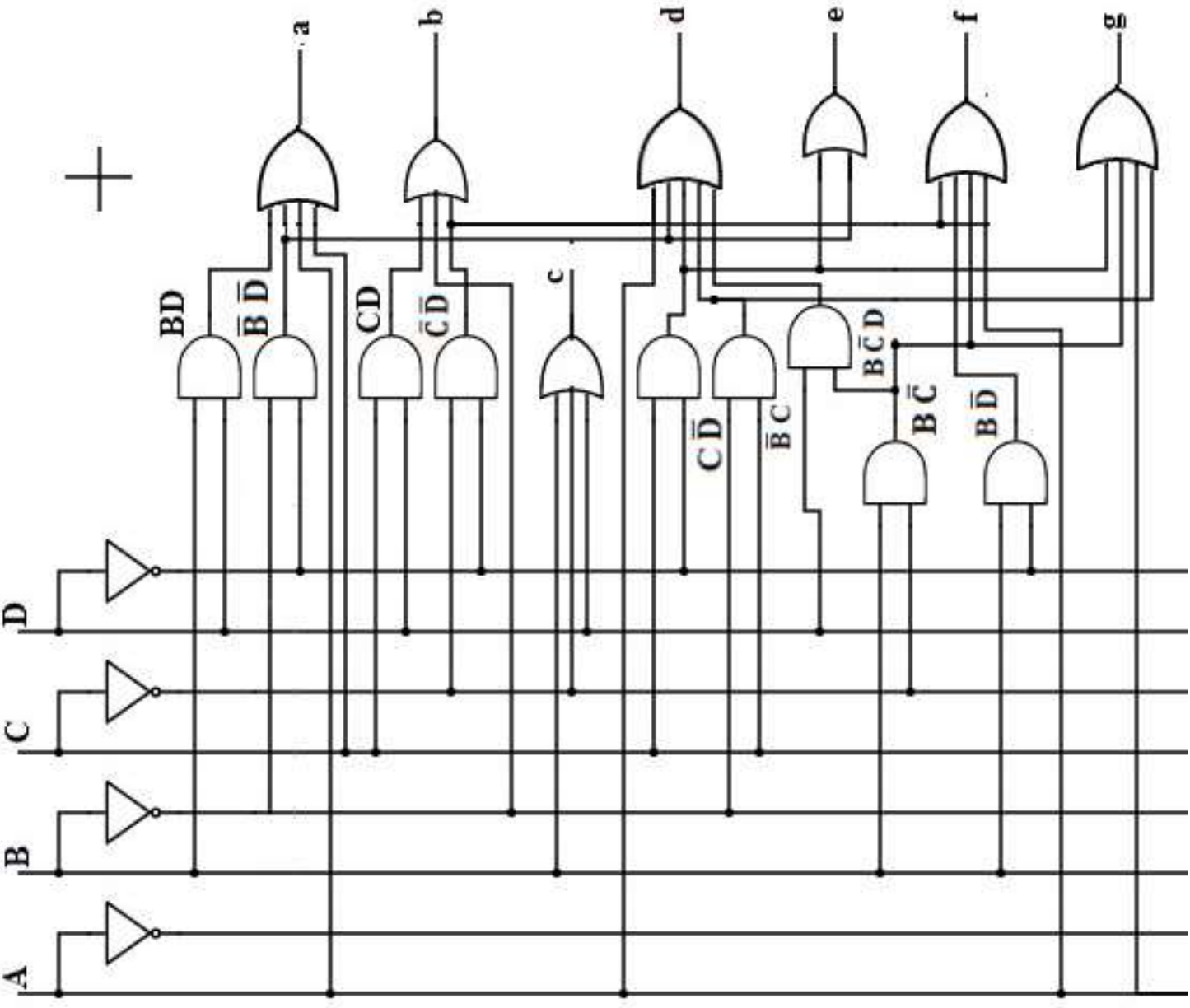
- Contains seven display units to form different numeric

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

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

Circuit Diag.

- Circuit can be implemented using few AND, OR and NOT gates only.



IC CD4543

- Latch Disable:
 - To latch the data on the output pins
- Phase:
 - Should be zero for common cathode while 1 for common anode 7-segment display.
- Blanking:
 - To blank the display by giving high input.
 - Normally connected to ground.

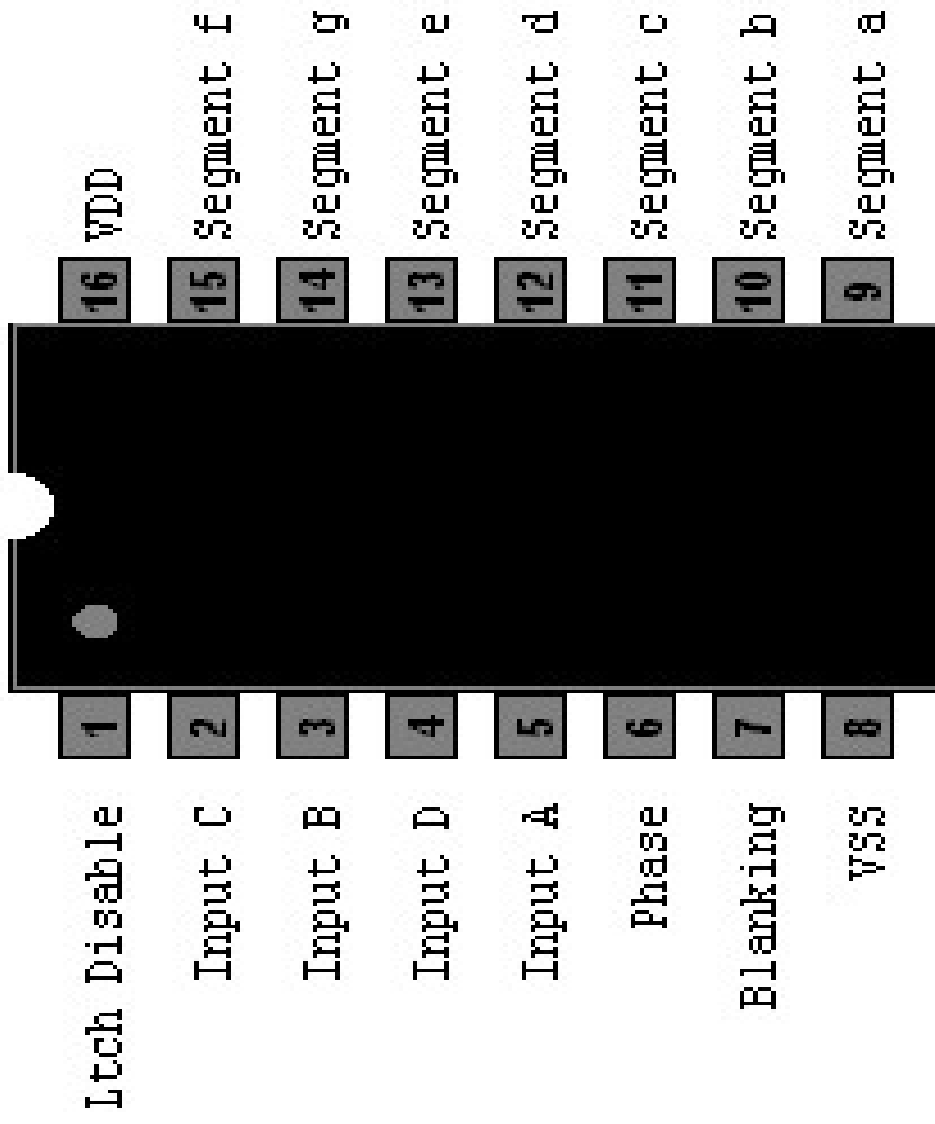


Table 3. Function table [1]

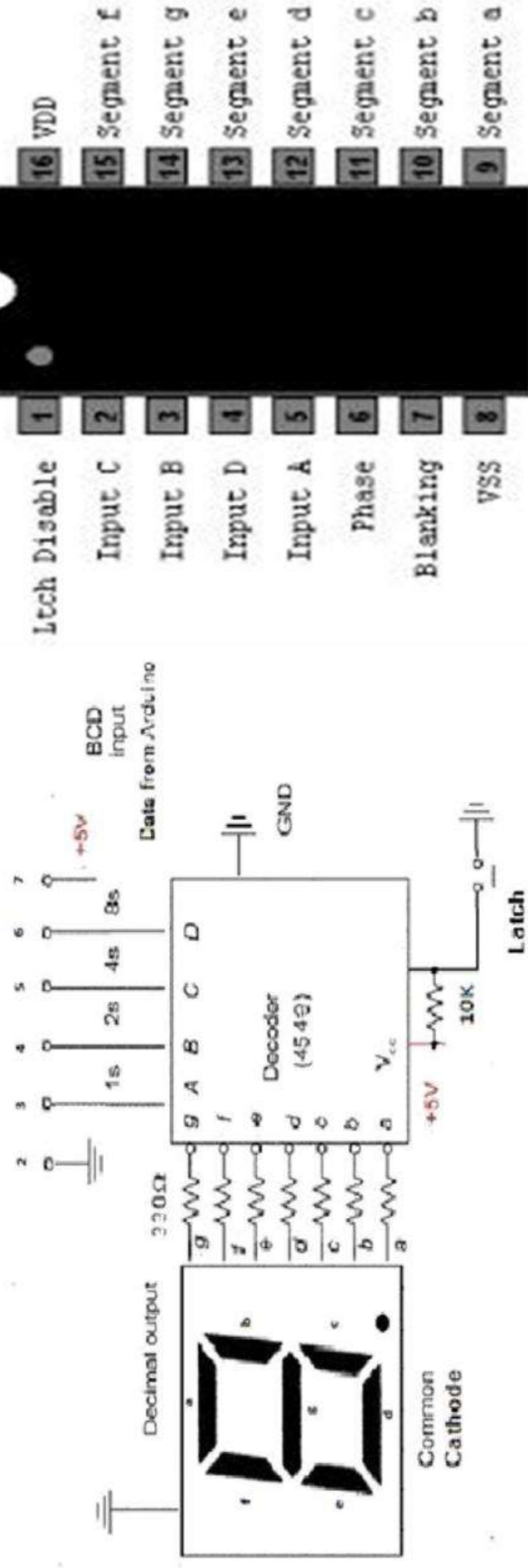
Inputs			Outputs										Display		
LE	BL	PH [2]	D3	D2	D1	D0	Qa	Qb	Qc	Qd	Qe	Qf	Qg	Qg	
X	H	L	X	X	X	X	L	L	L	L	L	L	L	L	blank
H	L	L	L	L	L	L	H	H	H	H	H	H	L	L	0
H	L	L	L	L	L	H	L	H	H	L	L	L	L	L	1
H	L	L	L	L	H	L	H	H	L	H	H	L	H	H	2
H	L	L	L	L	H	H	H	H	H	H	L	L	H	H	3
H	L	L	L	H	L	L	L	H	H	L	L	H	H	H	4
H	L	L	L	H	L	H	H	L	H	H	L	H	H	H	5
H	L	L	L	H	H	L	H	L	H	H	H	H	H	H	6
H	L	L	L	H	H	H	H	H	H	L	L	L	L	L	7
H	L	L	H	L	L	L	H	H	H	H	H	H	H	H	8
H	L	L	H	L	L	H	H	H	H	H	L	H	H	H	9
H	L	L	H	L	H	X	L	L	L	L	L	L	L	L	blank
H	L	L	H	H	X	X	L	L	L	L	L	L	L	L	blank
L	L	L	X	X	X	X	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.	n.c.
as above		H	as above				inverse of above								as above

[1] H = HIGH voltage level; L = LOW voltage level; X = don't care; n.c. = no change.

- [2] For liquid crystal displays, apply a square-wave to PH;
 For common cathode LED displays, select PH = LOW;
 For common anode LED displays, select PH = HIGH.

BCD-7-segment decoder

- The decoder (CD4543) is a combinational digital circuit that decodes an 4-bit binary input in the range 0000-1001 (BCD) in to its corresponding decimal level.
- It can latch (maintain the output) when the latch is low.



Code example

- The decimal integer can be converted into 4-bit binary number as follows
 - `int a=i%2; // calculate LSB`
 - `int b=i/2 %2;`
 - `int c=i/4 %2;`
 - `int d=i/8 %2; //calculate MSB`



Thanks

