Codes

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Binary Codes

- A binary code is defined as a coding system that uses two binary digits (0,1), to represent a letter or a number.
- Having n digits (each of 0,1), this n digits can code 2^n different elements.

Binary Coded Decimal (BCD)

Binary-Coded Decimal (BCD)

Decimal Symbol	BCD Digit
0	0000
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001

- BCD Code uses 4 bits to represent the 10 decimal digits {0 to 9}
- 6 BCD codes are unused {1010 – 1011 – 1100 – 1101 – 1110 – 1111}

Binary Coded Decimal (BCD)
(Examples)

Examples:

(5463)10=(?)BCD

From the previous table

5→0101 4→0100 6→0110 3→0011

So

(5463)10=(0101 0100 0110 0011)BCD

Binary Coded Decimal (BCD)
(Examples)

- $(1001\ 0111\ 0010.1000\ 0000\ 0010)_{BCD} = (\ ?)_{10}$
- $(1101\ 0111\ 0010.1000\ 0000\ 0010)_{BCD} = (\ ?)_{10}$

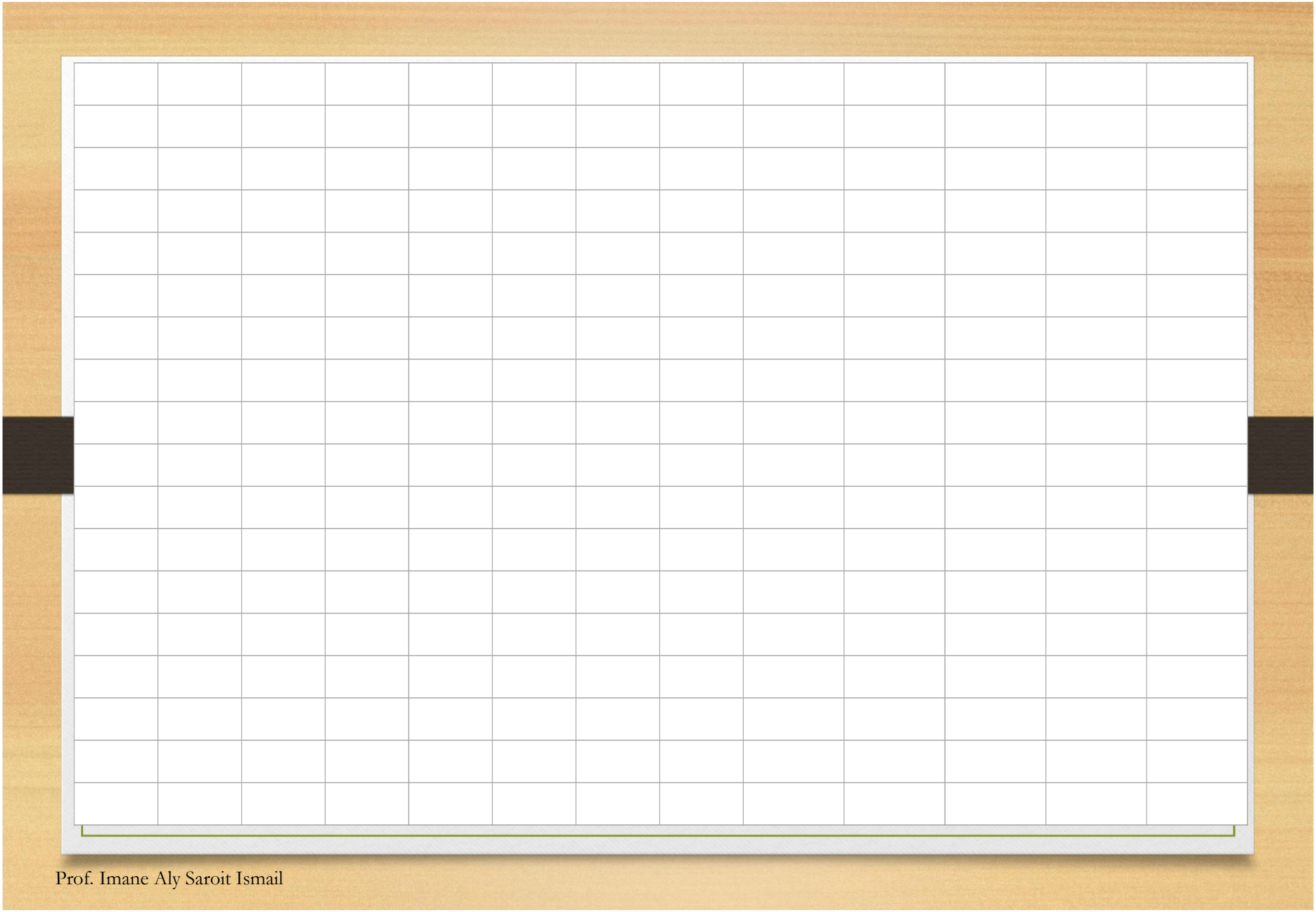
  Using the table

- $(1001\ 0111\ 0010.1000\ 0000\ 0010)_{BCD} = (972.802)_{10}$
- $(1101\ 0111\ 0010.1000\ 0000\ 0010)_{BCD}$ is not a BCD number is 1101 does not represents a BCD code.

Binary Coded Decimal (BCD)

Exercise:

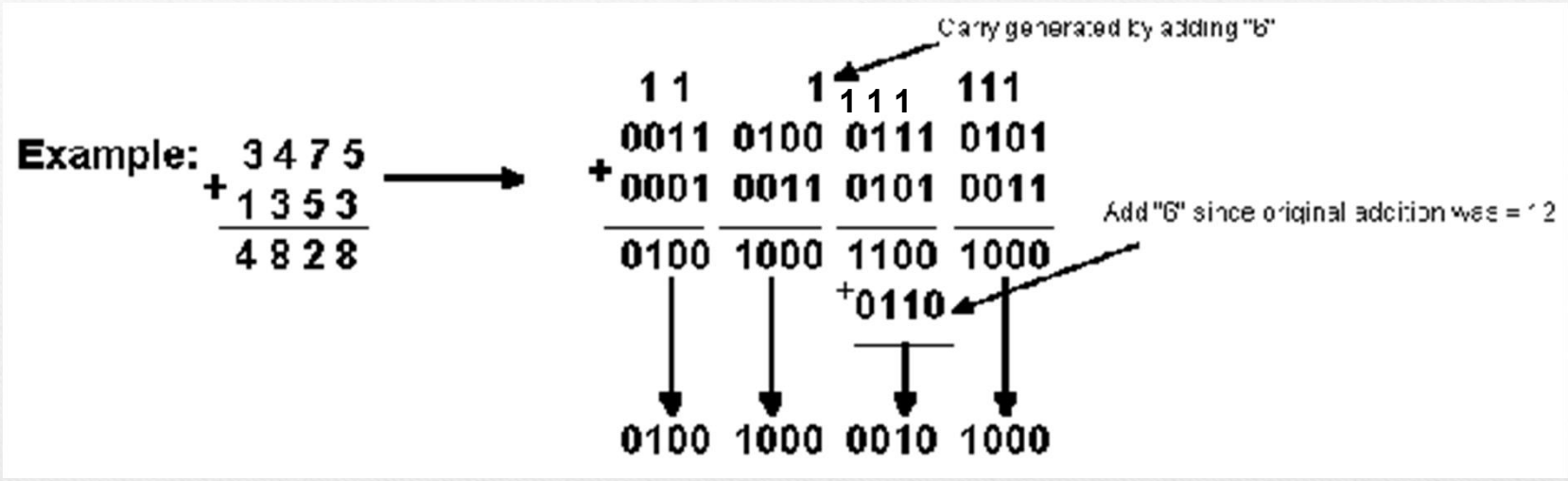
Determine the binary code for each of the decimal numbers (0,15) using 84-2-1 code.



Binary Coded Decimal (BCD) (Addition)

- Adding two BCD numbers together with a carry of 1 may lead to result =19 (9+9+1).
- As BCD can represent only numbers from 0 to 9, so when the resulting number of the addition is greater than 9 (invalid number). In this case we should add 6 (0110) to the result.

Binary Coded Decimal (BCD)
(Addition-Example)



Binary Coded Decimal (BCD)
(Addition)

Exercise:

Solve the solving problem:

- $(01000111.0010)_{BCD} + (01011000.01101000)_{BCD} = (?)_{BCD}$

$$(01000111.0010)_{BCD} + (01011000.01101000)_{BCD}$$

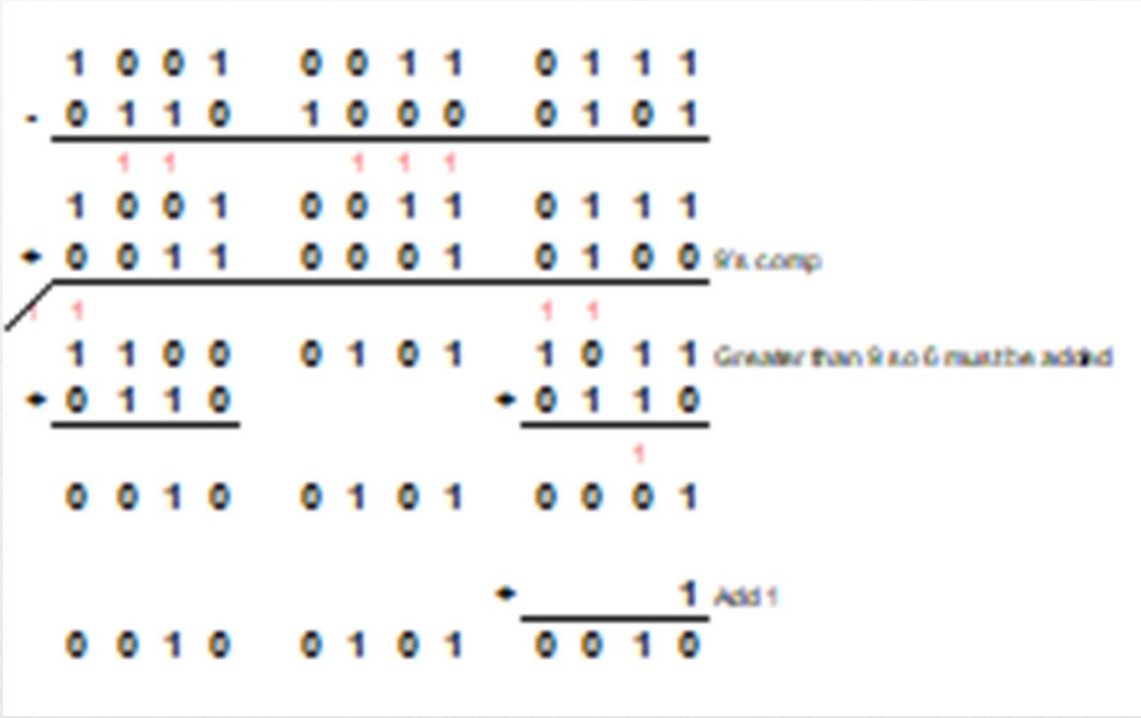
Binary Coded Decimal (BCD)
(Subtraction)

- $(A)_{BCD} - (B)_{BCD} = (A)_{BCD} + 9\text{'s Comp}(B)_{BCD} + 1$
- 9's Complement of a BCD code is the number which if added to the original code the sum will be 9.
- $9\text{'s Comp}(0101\ 0100\ 0110\ 0011)_{BCD}$

  $=(0100\ 0101\ 0011\ 0110)$

Binary Coded Decimal (BCD)

(Subtraction-Example)



Binary Coded Decimal (BCD)
(Subtraction)

Exercise:

Solve the solving problem:

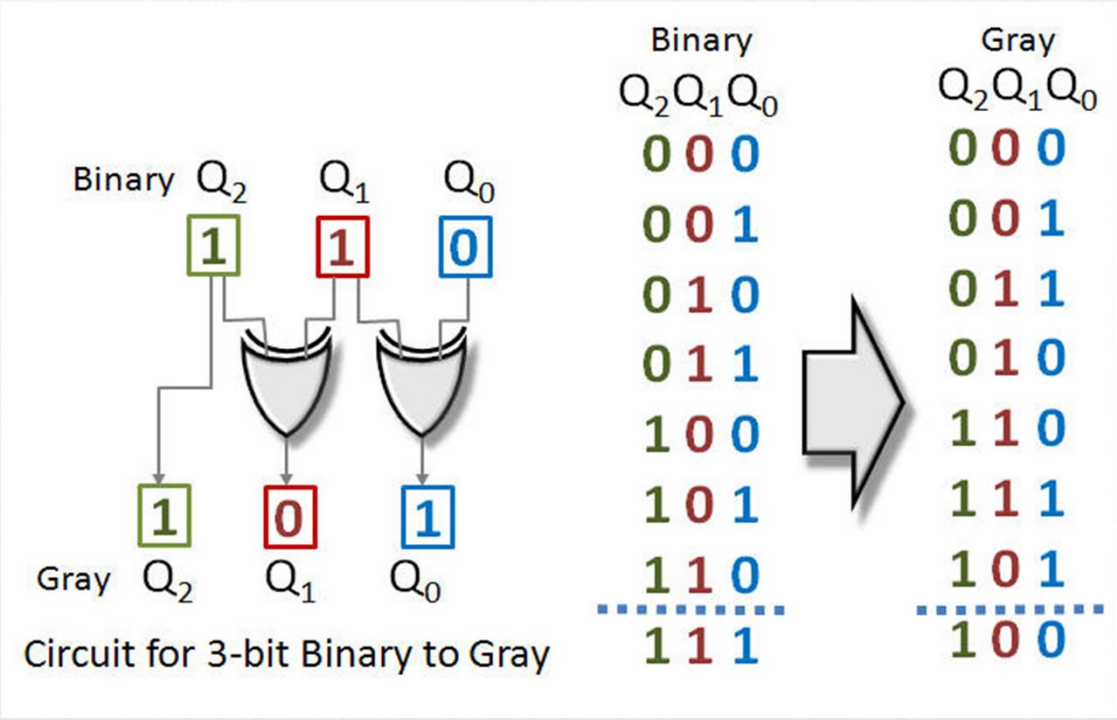
- $(011101011000.0110)_{BCD} - (01000111.00101000)_{BCD} = (?)_{BCD}$

$(011101011000.0110)_{BCD} - (01000111.00101000)_{BCD}$

Other Decimal Codes (Gray Code)

- The Gray code is defined as an ordering of the binary number system such that each incremental value can only differ by one bit. Meaning that only one bit in the code changes in going from one number to the next.
- For example in BCD code from 7 (0111) to 8 (1000) the whole four bits are changed, while in gray code from 7 (0100) to 8 (1100), only one bit changes.

Other Decimal Codes (Gray Code)



Other Decimal Codes

Table
Four Different Binary Codes for the Decimal Digits

Decimal Digit	BCD 8421	2421	Excess-3	8, 4, −2, −1
0	0000	0000	0011	0000
1	0001	0001	0100	0111
2	0010	0010	0101	0110
3	0011	0011	0110	0101
4	0100	0100	0111	0100
5	0101	1011	1000	1011
6	0110	1100	1001	1010
7	0111	1101	1010	1001
8	1000	1110	1011	1000
9	1001	1111	1100	1111
	1010	0101	0000	0001
Unused	1011	0110	0001	0010
bit	1100	0111	0010	0011
combi-	1101	1000	1101	1100
nations	1110	1001	1110	1101
	1111	1010	1111	1110

ASCII Code

- **The American Standard Code for Information Interchange (ASCII) code is a table or list containing all the letters of the alphabet plus a variety of additional characters. In this code, each character is represented by an order number, which is always the same.**

ASCII Code

- It is composed of 7 bits (i.e. $2^7 = 128$ characters)
  - 94 printable, 34 non-printable (control)
    - 2x26 English letters (A,…Z, a,…z)
    - 10 decimal digits (0,1,…9)
    - 32 special characters such as %, *, $, … etc.
    - 34 control characters (with special uses).
- Usually stored as a byte, where the extra bit is used for other purposes depending on the application..

ASCII Code

$b_4b_3b_2b_1$	$b_7b_6b_5$ = 000	001	010	011	100	101	110	111
0000	NUL	DLE	SP	0	@	P	`	p
0001	SOH	DC1	!	1	A	Q	a	q
0010	STX	DC2	"	2	B	R	b	r
0011	ETX	DC3	#	3	C	S	c	s
0100	EOT	DC4	$	4	D	T	d	t
0101	ENQ	NAK	%	5	E	U	e	u
0110	ACK	SYN	&	6	F	V	f	v
0111	BEL	ETB	'	7	G	W	g	w
1000	BS	CAN	(	8	H	X	h	x
1001	HT	EM	)	9	I	Y	i	y
1010	LF	SUB	*	:	J	Z	j	z
1011	VT	ESC	+	;	K	[	k	{
1100	FF	FS	,	<	L	\	l	|
1101	CR	GS	−	=	M	]	m	}
1110	SO	RS	.	>	N	^	n	~
1111	SI	US	/	?	O	−	o	DEL

ASCII Code

Control Characters

NUL	Null	DLE	Data-link escape
SOH	Start of heading	DC1	Device control 1
STX	Start of text	DC2	Device control 2
ETX	End of text	DC3	Device control 3
EOT	End of transmission	DC4	Device control 4
ENQ	Enquiry	NAK	Negative acknowledge
ACK	Acknowledge	SYN	Synchronous idle
BEL	Bell	ETB	End-of-transmission block
BS	Backspace	CAN	Cancel
HT	Horizontal tab	EM	End of medium
LF	Line feed	SUB	Substitute
VT	Vertical tab	ESC	Escape
FF	Form feed	FS	File separator
CR	Carriage return	GS	Group separator
SO	Shift out	RS	Record separator
SI	Shift in	US	Unit separator
SP	Space	DEL	Delete