Week 8

Binary Coded Decimal (BCD)

12- Binary Coded Decimal (BCD)

Binary Coded Decimal **BCD** system is an excellent way to provide an interface between Binary and Decimal System.

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

Convert Decimal Numbers to BCD

Convert each of the following decimal numbers to BCD:

(a) 35 **(b)** 98 **(c)** 170 **(d)** 2469

Solution

(a) 3 5 → **00110101**

(b) 9 8 → **10011000**

(c) 1 7 0 → **000101110000**

(d) 2 4 6 9 → **0010010001101001**

Related Problem Convert the decimal number 9673 to BCD.

Binary Coded Decimal (BCD)

What are the column weights for the BCD number

1000 0011 0101 1001?

8000 4000 2000 1000 800 400 200 100 80 40 20 10 8 4 2 1

Note that you could add the column weights where there is a 1 to obtain the decimal number. For this case:

$8000 + 200 + 100 + 40 + 10 + 8 + 1 = 8359_{10}$

Convert BCD **Numbers** to Decimal

Convert each of the following BCD codes to decimal:

(a) 10000110 **(b)** 001101010001 **(c)** 1001010001110000

Solution

(a) 10000110 → **8 6**

(b) 001101010001 → **3 5 1**

(c) 1001010001110000 → **9 4 7 0**

Related Problem Convert the BCD code 1000001000100111010 to decimal.

Assignment:

From the text book answer the following questions :

1. **How could we add BCD numbers ? give an example .**

13- Digital Codes

- Gray code
- ASCII code

Digital Codes

- Gray code

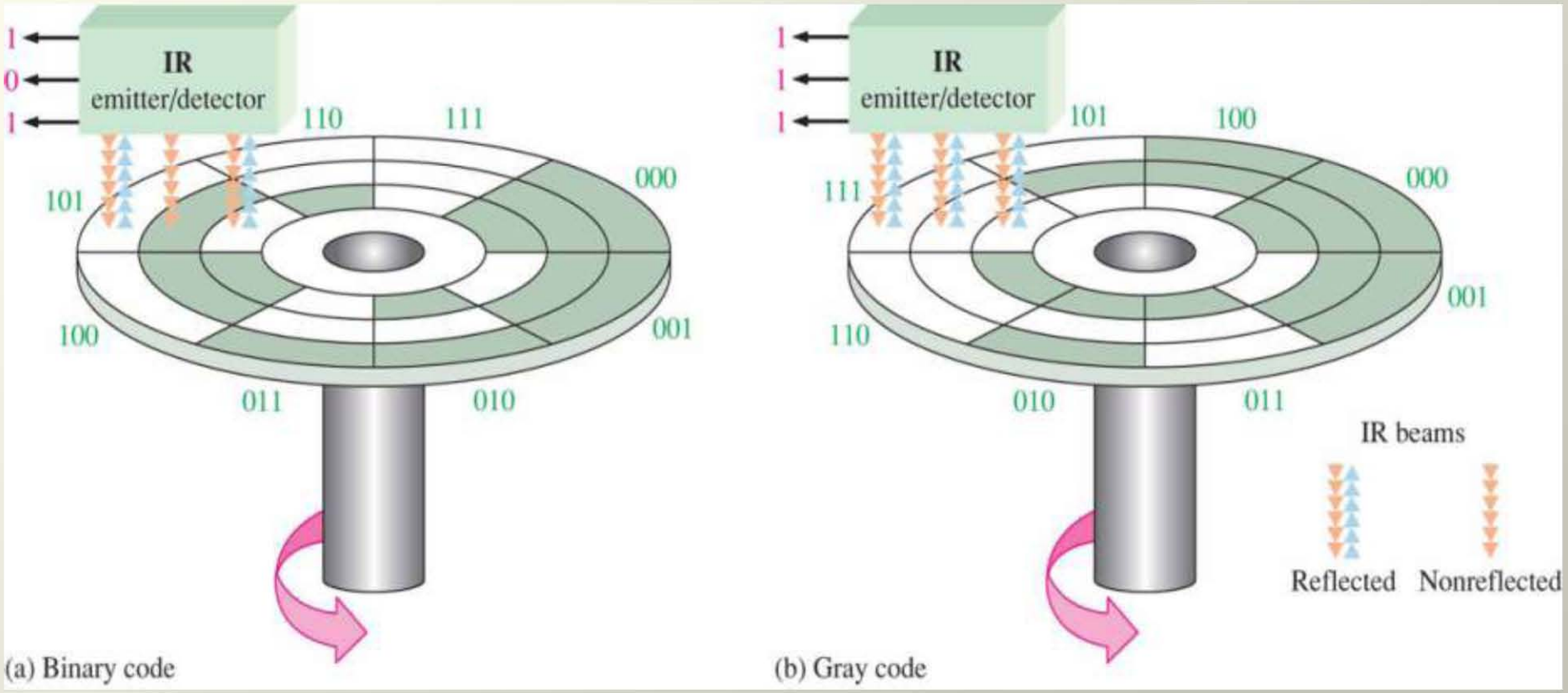
Gray code is an unweighted code that has a single bit change between one code word and the next in a sequence.

Gray code is used to avoid problems in systems where an error can occur if more than one bit changes at a time.

Decimal	Binary	Gray code
0	0000	0000
1	0001	0001
2	0010	0011
3	0011	0010
4	0100	0110
5	0101	0111
6	0110	0101
7	0111	0100
8	1000	1100
9	1001	1101
10	1010	1111
11	1011	1110
12	1100	1010
13	1101	1011
14	1110	1001
15	1111	1000

Gray code

A shaft encoder is a typical application. Three IR emitter/detectors are used to encode the position of the shaft. The encoder on the left uses binary and can have three bits change together, creating a potential error. The encoder on the right uses gray code and only 1-bit changes, eliminating potential errors.



Digital Codes: ASCII Code

American Standard Code for Information Interchange

ASCII is a code for alphanumeric characters and control characters. In its original form, ASCII encoded 128 characters and symbols using 7-bits. The first 32 characters are control characters, that are based on obsolete teletype requirements, so these characters are generally assigned to other functions in modern usage.

In 1981, IBM introduced extended ASCII, which is an 8-bit code and increased the character set to 256. Other extended sets (such as Unicode) have been introduced to handle characters in languages other than English.

Digital Codes

- ASCII code (control characters)

NAME	DEC	BINARY	HEX	NAME	DEC	BINARY	HEX
NUL	0	0000000	00	DLE	16	0010000	10
SOH	1	0000001	01	DC1	17	0010001	11
STX	2	0000010	02	DC2	18	0010010	12
ETX	3	0000011	03	DC3	19	0010011	13
EOT	4	0000100	04	DC4	20	0010100	14
ENQ	5	0000101	05	NAK	21	0010101	15
ACK	6	0000110	06	SYN	22	0010110	16
BEL	7	0000111	07	ETB	23	0010111	17
BS	8	0001000	08	CAN	24	0011000	18
HT	9	0001001	09	EM	25	0011001	19
LF	10	0001010	0A	SUB	26	0011010	1A
VT	11	0001011	0B	ESC	27	0011011	1B
FF	12	0001100	0C	FS	28	0011100	1C
CR	13	0001101	0D	GS	29	0011101	1D
SO	14	0001110	0E	RS	30	0011110	1E
SI	15	0001111	0F	US	31	0011111	1F

Digital Codes

- ASCII code (graphic symbols 20h – 3Fh)

SYMBOL	DEC	BINARY	HEX	SYMBOL	DEC	BINARY	HEX
space	32	0100000	20	0	48	0110000	30
!	33	0100001	21	1	49	0110001	31
"	34	0100010	22	2	50	0110010	32
#	35	0100011	23	3	51	0110011	33
$	36	0100100	24	4	52	0110100	34
%	37	0100101	25	5	53	0110101	35
&	38	0100110	26	6	54	0110110	36
'	39	0100111	27	7	55	0110111	37
(	40	0101000	28	8	56	0111000	38
)	41	0101001	29	9	57	0111001	39
*	42	0101010	2A	:	58	0111010	3A
+	43	0101011	2B	;	59	0111011	3B
,	44	0101100	2C	<	60	0111100	3C
–	45	0101101	2D	=	61	0111101	3D
.	46	0101110	2E	>	62	0111110	3E
/	47	0101111	2F	?	63	0111111	3F

Digital Codes

- ASCII code (graphic symbols 40h – 5Fh)

SYMBOL	DEC	BINARY	HEX	SYMBOL	DEC	BINARY	HEX
@	64	1000000	40	P	80	1010000	50
A	65	1000001	41	Q	81	1010001	51
B	66	1000010	42	R	82	1010010	52
C	67	1000011	43	S	83	1010011	53
D	68	1000100	44	T	84	1010100	54
E	69	1000101	45	U	85	1010101	55
F	70	1000110	46	V	86	1010110	56
G	71	1000111	47	W	87	1010111	57
H	72	1001000	48	X	88	1011000	58
I	73	1001001	49	Y	89	1011001	59
J	74	1001010	4A	Z	90	1011010	5A
K	75	1001011	4B	[	91	1011011	5B
L	76	1001100	4C	\	92	1011100	5C
M	77	1001101	4D	]	93	1011101	5D
N	78	1001110	4E	^	94	1011110	5E
O	79	1001111	4F	_	95	1011111	5F

Digital Codes

- ASCII code (graphic symbols 60h – 7Fh)

SYMBOL	DEC	BINARY	HEX	SYMBOL	DEC	BINARY	HEX
`	96	1100000	60	p	112	1110000	70
a	97	1100001	61	q	113	1110001	71
b	98	1100010	62	r	114	1110010	72
c	99	1100011	63	s	115	1110011	73
d	100	1100100	64	t	116	1110100	74
e	101	1100101	65	u	117	1110101	75
f	102	1100110	66	v	118	1110110	76
g	103	1100111	67	w	119	1110111	77
h	104	1101000	68	x	120	1111000	78
i	105	1101001	69	y	121	1111001	79
j	106	1101010	6A	z	122	1111010	7A
k	107	1101011	6B	{	123	1111011	7B
l	108	1101100	6C	|	124	1111100	7C
m	109	1101101	6D	}	125	1111101	7D
n	110	1101110	6E	~	126	1111110	7E
o	111	1101111	6F	Del	127	1111111	7F

Digital Codes

Extended ASCII code (80h – FFh)

- Non-English alphabetic characters
- Currency symbols
- Greek letters
- Math symbols
- Drawing characters
- Bar graphing characters
- Shading characters

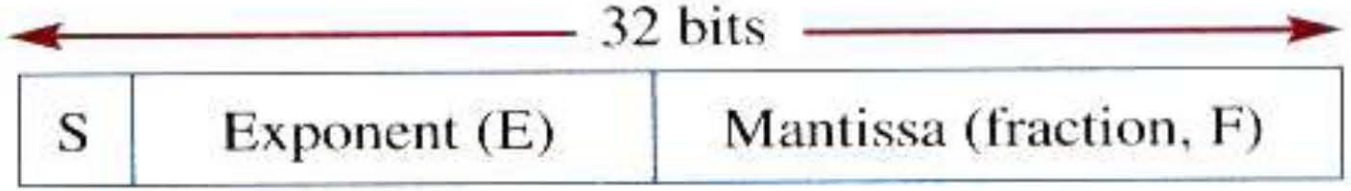
14- Floating point Binary Numbers

A floating-point number consists of the two parts :

1. **The Mantissa (العشري) which represents the magnitude of the number.**
2. **The exponent which represents the number of places the decimal point is to be moved .**

Example :
The decimal number 241506800 is represented as :

$$0.2415068 \times 10^{9}$$



Key Terms of lecture-2

- Byte
- LSB
- MSB
- Hexadecimal numbers
- BCD
- ASCII
- Alphanumeric