

# Gray and Alphanumeric Codes

## Lecture 05 Book Chapter(s): 1

COE211-Digital Logic Design

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# The Gray Code

- Unweighted (not an arithmetic code)
- Only a *single bit change* from one code number to the next
- Good for error detection

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

- How to generate 5-bit standard Gray code?
- How to generate  $n$ -bit standard Gray code?

# Binary-to-Gray Code Conversion

- Retain most significant bit
- From left to right, add each adjacent pair of binary code bits to get the next Gray code bit, discarding carries
- Example: Convert binary number 10110 to Gray code

1	0	1	1	0	Binary
↓					
1					Gray

1	+	0	1	1	0	Binary
		↓				
1		1				Gray

1	0	+	1	1	0	Binary
			↓			
1	1		1			Gray

1	0	1	+	1	0	Binary
				↓		
1	1	1		0		Gray

1	0	1	1	+	0	Binary
				↓		
1	1	1	0	1		Gray

$$(10110)_2 = (11101)_{\text{Gray}}$$

# Gray-to-Binary Code Conversion

- Retain most significant bit
- From left to right, add each binary code bit generated to the Gray code bit in the next position, discarding carries
- Example: Convert Gray code 11011 to binary

1	1	0	1	1	Gray
↓					
1					Binary

1		1	0	1	1	Gray
	+	↓				
1		0				Binary

1	1	0	1	1	Gray
		+	↓		
1	0	0			Binary

1	1	0		1	1	Gray
			+	↓		
1	0	0		1		Binary

1	1	0	1		1	Gray
				+	↓	
1	0	0	1		0	Binary

$$(11011)_{\text{Gray}} = (10010)_2$$

# Alphanumeric Codes (1)

- Apart from numbers, computers also handle textual data
- Character set frequently used includes:
  - alphabets: 'A' ... 'Z', and 'a' ... 'z'
  - digits: '0' ... '9'
  - special symbols: '\$', '.', ',', '@', '\*', ...
  - non-printable: SOH, NULL, BELL, ...
- Usually, these characters can be represented using 7 or 8 bits

# Alphanumeric Codes (2)

- Two widely used standards:

1. **ASCII** (American Standard Code for Information Interchange):

7-bit, plus a *parity bit* for error detection (odd/even parity)

2. **EBCDIC** (Extended BCD Interchange Code)

EBCDIC: 8-bit code

Character	ASCII Code
0	0110000
1	0110001
...	...
9	0111001
:	0111010
A	1000001
B	1000010
...	...
Z	1011010
[	1011011
\	1011100

# Alphanumeric Codes (3)

- ASCII Table

LSBs	MSBs							
	000	001	010	011	100	101	110	111
0000	NUL	DLE	SP	0	@	P	^	p
0001	SOH	DC <sub>1</sub>	!	1	A	Q	a	q
0010	STX	DC <sub>2</sub>	"	2	B	R	b	r
0011	ETX	DC <sub>3</sub>	#	3	C	S	c	s
0100	EOT	DC <sub>4</sub>	\$	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	O	RS	.	>	N	^	n	~
1111	SI	US	/	?	O	_	o	DEL