

# Digital Logic & Design

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Lecture 03

# Recap

- Number System Conversion
  - Sum-of-Weights for converting to decimal
  - Repeated division for converting from decimal
- Binary Arithmetic
  - Similar to Decimal Arithmetic
  - Multiplying by a constant by shifting left
  - Dividing by a constant by shifting right

# Recap

- Representing Numbers
  - Unsigned
  - Signed Magnitude
  - 2's Complement

# Number system and conversation

- Decimal
- Binary
- Octal
- Hexadecimal

Note: we will use board to cover number system topic

# Alternate Representations

- BCD Code
  - BCD Addition
- Gray Code

# BCD to 7 segment display

BCD Signal				Display	BCD Signal				Display
D	C	B	A		D	C	B	A	
0	0	0	0	0	0	1	0	1	5
0	0	0	1	1	0	1	1	0	6
0	0	1	0	2	0	1	1	1	7
0	0	1	1	3	1	0	0	0	8
0	1	0	0	4	1	0	0	1	9

0 = logic low

1 = logic high

# Alternate Representations

- BCD (Binary Coded Decimal) Code

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

# BCD Addition

- Multi-digit BCD numbers can be added together

23      0010 0011

45      0100 0101

68      0110 1000

23      0010 0011

48      0100 1000

71      0110 1011

- 1011 is illegal BCD number



# BCD Addition

- Add a 0110 (6) to an invalid BCD number
- Carry added to the most significant BCD digit

23	0010 0011
<u>48</u>	<u>0100 1000</u>
71	0110 1011
	<u>0110</u>
	<u>0111 0001</u>

# Gray Code

- Binary Code more than 1 bit change
- Binary to gray
- Gray to binary

# Gray Code

Decimal	Gray	Binary
0	0000	0000
1	0001	0001
2	0011	0010
3	0010	0011
4	0110	0100
5	0111	0101
6	0101	0110
7	0100	0111

# Alphanumeric Code

- Numbers, Characters, Symbols
- ASCII 7-bit Code
- American Standard Code for Information Interchange
- 10 Numbers (0-9)
- 26 Lower Case Characters (a-z)
- 26 Upper Case Characters (A-Z)
- Punctuation and Symbols
- 32 Control Characters

# Alphanumeric Code

- Extended ASCII 8-bit Code
- Additional 128 Graphic characters
- Unicode 16-bit Code

# Error Detection

- Digital Systems are very Reliable
- Errors during storage or transmission
- Parity Bit
  - Even Parity
  - Odd Parity

# Odd Parity Error Detection

- Original data     10011010
- With Odd Parity 110011010
- 1-bit error     110111010
- Number of 1s even indicates 1-bit error
- 2-bit error     110110010
- Number of 1s odd no error indicated
- 3-bit error     100110010
- Number of 1s even indicates error