ECE213: Digital Electronics

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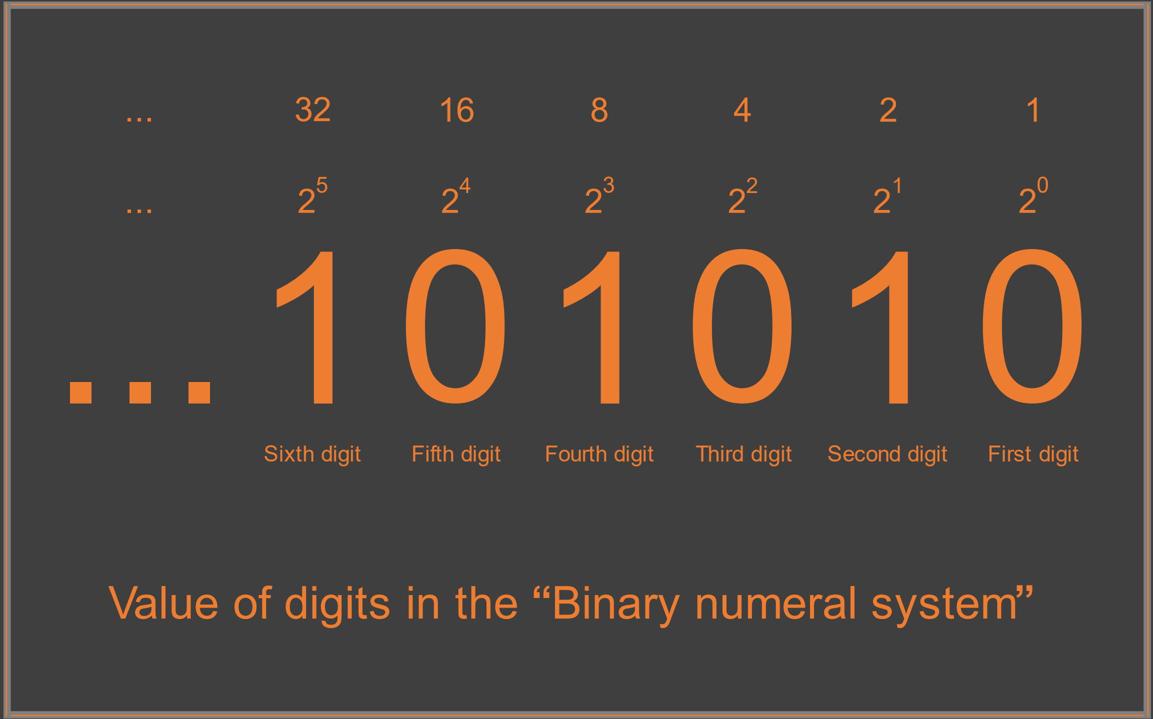
The Course Contents

Unit I

Number Systems : Digital Systems, Data representation and coding, Logic circuits, Implementation of digital systems, Number Systems, Codes- Positional number system, Binary number system, Methods of base conversions, Binary arithmetic, Representation of signed numbers, Fixed numbers, Binary coded decimal codes, Gray codes, Error detection code, Parity check codes, octal number system, Hexadecimal number system, Error correction code, Hamming code, Octal arithmetic, Hexadecimal arithmetic, Floating point numbers



Number Systems

Error detection code - Hamming code

2 Mbps

$2 \times 10^{10} \times 8$

$2^n - 1$

what should be the size of hamming code.

	p	l	D
Ex	$n=1$	1	0
Costly	$n=2$	3	1
#	$\boxed{n=3 \quad 7}$		4
	$n=4$	15	11
	$n=5$	31	
	⋮	⋮	

How many parity bits.

Ans n

How many data bits

Ans $2^n - 1 - n = d$

Number Systems

Error detection code - Hamming code

☆ 7-bit format of Hamming code

parity bit position.

data bit positions

Total	p	d
7	3	4

poly.

$2^0 \; 2^1 \; 2^2 \; 2^3 \; 2^4 \; 2^5 \; \ldots$

⇒ This will tell you the positions of parity bits.

7-bit	1	2	4		
15-bit	1	2	4	8	
31 bit	1	2	4	8	16

Number Systems

Error detection code - Hamming code

Ex Write the 7-bit hamming code for data $D = 1101$.

Even

1	0	1	0	1	0	1
p_1	p_2		p_4			

$\Rightarrow p_1\ (1, 3, 5, 7)$

$\Rightarrow p_2\ (2, 3, 6, 7)$

$\Rightarrow p_4\ (4, 5, 6, 7)$

The 7-bit even parity hamming code for Data $D = 1101$ is

$C = 1010101$

* Type of Parity

(i) Even

(ii) odd.

Q: How we get to know that which bit possition are responsible for which parity bit

A:

p_4	p_2	p_1	
0	0	0	0
0	0	1	1 ✓
0	1	0	2
0	1	1	3 ✓
1	0	0	4
1	0	1	5 ✓
1	1	0	6
1	1	1	7 ✓

Number Systems

Error detection code - Hamming code

Ex
D = 1111

Error

$\frac{1}{1}$ $\frac{1}{2}$ $\underline{1}$ $\frac{1}{4}$ $\underline{1}$ $\underline{1}$ $\underline{1}$

C = 1111111

Ex
D = 1001

0 0 1 1 0 0 1

Ex odd parity hamming code
D = 1111

0 0 1 0 1 1 1

Ex odd parity hamming code
D = 1001

1 1 1 0 0 0 1

Number Systems

Q. Write 7-bit Right to left odd Parity hamming code.

Error detection code - Hamming code

D=1101

☆ Left to Right

		1		1	0	1
1	2	3	4	5	6	7
p_1	p_2		p_4			

☆ Right to left

1	1	0		1		
7	6	5	4	3	2	1
			p_4		p_2	p_1

Even

(A) 1 0 1 0 1 0 1

odd

(B) 0 1 1 1 1 0 1

(C) 1 1 0 0 1 1 0

(D) 1 1 0 1 1 0 1

Number Systems

Error detection code - Hamming code

Ex Find the 7-bit Right to left even parity hamming code for the Given data.

$D = 0011010101011011$

D_3 D_2 D_1

Sol. for D_1

1 0 1 0 1 0 1

P_4 P_2 P_1

$C_1 = 1010101$

For D_3

0 0 1 1 1 1 0

$C_3 = 0011110$

for D_2 0 1 0 1 1 0 1

$C_2 = 0101101$

$C = 0011110\ 0101101\ 1010101$

Number Systems

What is the 7-bit hamming code for data 1101? Consider odd parity, left to right format

a) 1100110

b) 1101101

c) 1010101

d) 0111101 ✓

→ 0 1 1 1 1 0 1

0111101

Number Systems

Error detection code - Hamming code

Ex A 7-bit L → R even parity hamming code is received find the data

C = 1010110

Sol:

1 0 1 0 1 1 0

$p_1(1, 3, 5, 7)$ error $e_1 = 1$

$p_2(2, 3, 6, 7)$ No error $e_2 = 0$

$p_4(4, 5, 6, 7)$ No error $e_3 = 0$

$e_3\ e_2\ e_1$

0 0 1 $\xrightarrow{\text{Dec}}$ 1^{st}

Correct code is C = 0010110

$\boxed{D = 1110}$ → Ans.

Number Systems

Error detection code - Hamming code

Ex: find the data bits for the 7-bits L-R even parity hamming codes

$C_1 = 1010101$

$e_1 = 0$
$e_2 = 0$
$e_3 = 0$

No error in the received code.

$\boxed{D = 1101}$

$C_2 = 1111110$

1 1 1 1 1 1 0

$e_1 = 1$
$e_2 = 1$
$e_3 = 1$

$e_3 e_2 e_1$ Dec
1 1 1 → 7^{th}

correct code $C_2 = 1111111$

$\boxed{D = 1111}$

Number Systems

Error detection code - Hamming code

Ex Send the Data D using 7-bit even parity L→R hamming code.

$\boxed{D = 1011}$

Sol →

0 1 1 0 0 1 1

C = 0110011

1-bit error

C = 0110001

$e_1 = 0$
$e_2 = 1$
$e_3 = 1$

$e_3 e_2 e_1$ Dec
1 1 0 → 6th

correct code → C = 0110011

$\boxed{D = 1011}$

2-bit error

C = 0110101

$e_1 = 1$
$e_2 = 1$
$e_3 = 0$

$e_3 e_2 e_1$ Dec
0 1 1 → 3rd

Correct code. C = 0100101

Note:- Hamming code can only correct up to 1-bit error.

Number Systems

The corrected 4-bit data after decoding the 7-bit hamming code 1101101?

Consider the even parity, left to right format

a) 0001

b) 0101

c) 1101

d) 1111

Number Systems

32 bits

IEEE 754 single-precision binary floating-point format: binary32

The IEEE 754 standard specifies a binary32 as having:

- Sign bit: 1 bit
- Exponent width: 8 bits
- Significand precision: 24 bits (23 explicitly stored)

0 +ve
1 -ve

Sign

Number Systems

IEEE 754 single-precision binary floating-point format: binary32

Ex $(3.25)_{10} = (11.01)_2 = 1.101 \times 2^{1}$

$\times$ 11.01×2^{0}
$\times$ 110.1×2^{-1}
$\times$ 1101×2^{-2}
$\checkmark$ $\boxed{1.101 \times 2^{1}}$ Normalized
$\times$ 0.1101×2^{2}
$\times$ 0.01101×2^{3}

s	1+127 e	m
0	10000000	10100000000000000000000
sign(1)	Exponent(8)	fraction(23)

Biased Exponent

Bias – 127 for 32 bit format

$1+127=128$

To get the decimal number

$$\boxed{N = (-1)^{s}\left(1.m \times 2^{(e-127)}\right)}$$

9.342×10^{6}
93.42×10^{5}
934.2×10^{4}
9342×10^{3}
93420000×10^{0}
934200000×10^{-1}
$9342000000 \times 10^{-2}$
⋮
0.9342×10^{7}
0.09342×10^{8}
0.009342×10^{9}

Dec

Number Systems

IEEE 754 single-precision binary floating-point format: binary32

☆ Why $\boxed{\text{Bias of } 127}$

Ans. To repr the +ve and −ve powers

$2^n - 1 = 2^8 - 1 = 255$

0000 0000	— 0	+ve
⋮		
1111 1111	— 255	

0000 0000	−127
⋮	
0111 1111	— 0
1000 0000	— 1
⋮	
1111 1111	+128