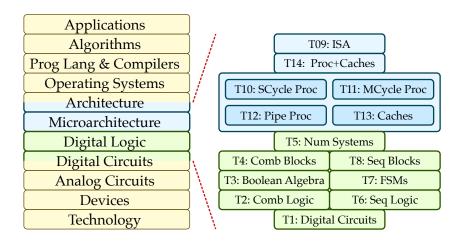
ECE 2300 Digital Logic and Computer Organization Fall 2025

Topic 5: Number Systems

School of Electrical and Computer Engineering Cornell University

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1. Unsigned Binary Number System

v_{bin}	$v_{dec} = b_3 \times 2^3 + b_2 \times 2^2 + b_1 \times 2^1 + b_0 \times 2^0$
$b_3b_2b_1b_0$ v_{dec}	How do we represent $v_{dec} = 13$ in binary?
0000	
0001	
0010	
0011	
0100	What does $v_{bin} = 1010$ represent in decimal?
0101	
0110	
0111	
1000	
1001	Hamilton and the state of the s
1010	How do we represent $v_{dec} = 14$ in binary?
1011	
1100	
1101	
1110	
1111	What does $v_{bin} = 1011$ represent in decimal?

2. Sign Magnitude Number System

v_{hin}	$v_{dec} = -1^{b_3} \times (b_2 \times 2^2 + b_1 \times 2^1 + b_0 \times 2^0)$
$b_3b_2b_1b_0$ v_{dec}	How do we represent $v_{dec} = -5$ in binary?
0000	
0001	
0010	
0011	
0100	What does $v_{bin} = 1100$ represent in decimal?
0101	
0110	
0111	
1000	
1001	
1010	How do we represent $v_{dec} = -7$ in binary?
1011	
1100	
1101	
1110	
1111	What does $v_{bin} = 0101$ represent in decimal?

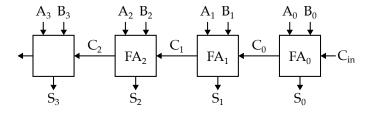
Complementing a signed magnitude r	number
• Simply invert the sign bit (i.e., the	most significant bit)
Implement an addsub unit for signed	magnitude numbers

3. Two's Complement Number System

	. (-2)210
v_{bin}	$v_{dec} = b_3 \times -(2^3) + b_2 \times 2^2 + b_1 \times 2^1 + b_0 \times 2^0$
$b_3b_2b_1b_0$ v_{dec}	How do we represent $v_{dec} = -4$ in binary?
0000	
0001	
0010	
0011	
0100	What does $v_{bin} = 1110$ represent in decimal?
0101	
0110	
0111	
1000	
1001	II
1010	How do we represent $v_{dec} = -1$ in binary?
1011	
1100	
1101	
1110	
1111	What does $v_{bin} = 0101$ represent in decimal?

Unsigned Binary Addition

Two's Complement Addition



C_2	A_3	В3	place value	sum	ovf S ₃
0	0	0			
0	0	1			
0	1	0			
0	1	1			
1	0	0			
1	0	1			
1	1	0			
1	1	1			

For subtraction, need to complement a two's complement number

	$b_3b_2b_1b_0$	v_{dec}	$-v_{dec}$			
0	0000	0	0	0000	0	16 - 0 = 16
1	0001	1	-1	1111	15	16 - 1 = 15
2	0010	2	-2	1110	14	16-2 = 14
3	0011	3	-3	1101	13	16 - 3 = 13
4	0100	4	-4	1100	12	16-4 = 12
5	0101	5	- 5	1011	11	16 - 5 = 11
6	0110	6	-6	1010	10	16 - 6 = 10
7	0111	7	-7	1001	9	16 - 7 = 9
8	1000	-8		1000	8	16 - 8 = 8
9	1001	-7	7	0111	7	16 - 9 = 7
10	1010	-6	6	0110	6	16 - 10 = 6
11	1011	-5	5	0101	5	16 - 11 = 5
12	1100	-4	4	0100	4	16 - 12 = 4
13	1101	-3	3	0011	3	16 - 13 = 3
14	1110	-2	2	0010	2	16 - 14 = 2
15	1111	-1	1	0001	1	16 - 15 = 1

The *two's complement* to a number v_{dec} with respect to 2^N is $2^N - v$

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		•m	ent	t ar	ad	dsı	ab	ur	nit	for	r t		o's	co		ole		en	tr		mb	er	S				
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4. Fixed Point Number System

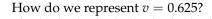
$b_3b_2b_1b_0$ v	$v = b_3 \times 2^1 + b_2 \times 2^0 + b_1 \times 2^{-1} + b_0 \times 2^{-2}$
0000	How do we represent $v = 1.5$?
0001	
0010	
0011	
0100	
0101	What does $b = 1011$ represent?
0110	
0111	
1000	
1001	
1010	How do we represent $v = 3.25$?
1011	
1100	
1101	
1110	
1111	How do we represent $v = 3.33$?
	$\frac{11000 \text{ do we represent } v = 0.000}{100000000000000000000000000000000$

5. Floating Point Number System

$b_3b_2b_1b_0$	v
0000	0.2500
0001	0.3125
0010	0.3750
0011	0.4375
0100	0.5000
0101	0.6250
0110	0.7500
0111	0.8750
1000	1.0000
1001	1.2500
1010	1.5000
1011	1.7500
1100	2.0000
1101	2.5000
1110	3.0000
1111	3.5000

$$v = 2^{(b_3 \times 2^1 + b_2 \times 2^0) - 2} \times (1 + b_1 \times 2^{-1} + b_0 \times 2^{-2})$$

- b_3b_2 is called the exponent part
 - $-b_3b_2 = 00$ represents 0.25 (subrange 0.25–0.50)
 - $-b_3b_2 = 01$ represents 0.50 (subrange 0.50–1.00)
 - $-b_3b_2 = 10$ represents 1.00 (subrange 1.00–2.00)
 - $-b_3b_2 = 11$ represents 2.00 (subrange 2.00–4.00)
- b_1b_0 is called the fraction part
 - fraction part divides up subrange



How do we represent v = 0.33?