ECE/CS 252 – Discussion – Week 03

ECE/CS 252
Intro to Computer Engineering

Week 03 Discussion

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Fractional Powers of 2

- Given a 7-bit binary number with 3 fractional bits, what is the weight of each bit position?

$$XXXXXXX_2$$

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Signed Fixed-Point

- Fixed-point also works with signed numbers
  - In digital audio processing, we often use 16-bit values in "Q15" format
    - 15 fractional bits in 2's-complement representation
      - $X.XXX\ XXXX\ XXXX\ XXXX_2$
    - What is the most positive value?
      - $0.111\ 1111\ 1111\ 1111_2$
      - $0.9999695_{10} \approx 1.0_{10}$
    - What is the most negative value?
      - $1.000\ 0000\ 0000\ 0000_2$
      - -1.0_{10}
- In this class, we only require you to do unsigned fixed-point representations!

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Floating-Point Issues

$(-1)^{[sign]} \times 1.[significand] \times 2^{([exp] - bias)}$

- Comparing two floating point numbers using exact equality often leads to software bugs
  - Let float X = 0.1_{10}
  - Is X+X+X+X+X+X+X+X+X+X = 10_{10}·X?
    - 1.00000012 ≠ 1.00000000!
      - 0x3F80000001 ≠ 0x3F80000000
  - Is sin(X) = sqrt(1 – $\cos^2$(X))?
    - 0.0998334214 ≠ 0.0998332202!
- How can we deal with this?

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Precision and Range

- Note: **precision** in number representation is defined as the <u>number of significant digits</u>
- Comparing 6-bit unsigned binary representations

Representation	Precision	Range
unsigned integer		
unsigned fixed-point with 1 fractional bit		
unsigned fixed-point with 2 fractional bits		
unsigned floating-point with 2 exponent bits (no bias)		
unsigned floating-point with 3 exponent bits (no bias)		

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Fixed- vs. Floating-Point

- Why not always floating-point?

- Why not always fixed-point?

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ASCII

- Characters represented in binary by a number

'3' $4A_{16}$ "ASCII"

HEX	CHAR	HEX	CHAR	HEX	CHAR	HEX	CHAR	HEX	CHAR	HEX	CHAR	HEX	CHAR	HEX	CHAR
00	**NUL**	10	**DLE**	20	space	30	0	40	@	50	P	60	`	70	p
01	**SOH**	11	**DC1**	21	!	31	1	41	A	51	Q	61	a	71	q
02	**STX**	12	**DC2**	22	"	32	2	42	B	52	R	62	b	72	r
03	**ETX**	13	**DC3**	23	#	33	3	43	C	53	S	63	c	73	s
04	**EOT**	14	**DC4**	24	$	34	4	44	D	54	T	64	d	74	t
05	**ENQ**	15	**NAK**	25	%	35	5	45	E	55	U	65	e	75	u
06	**ACK**	16	**SYN**	26	&	36	6	46	F	56	V	66	f	76	v
07	**BEL**	17	**ETB**	27	'	37	7	47	G	57	W	67	g	77	w
08	**BS**	18	**CAN**	28	(	38	8	48	H	58	X	68	h	78	x
09	**HT**	19	**EM**	29	)	39	9	49	I	59	Y	69	i	79	y
0A	**LF**	1A	**SUB**	2A	*	3A	:	4A	J	5A	Z	6A	j	7A	z
0B	**VT**	1B	**ESC**	2B	+	3B	;	4B	K	5B	[	6B	k	7B	{
0C	**FF**	1C	**FS**	2C	,	3C	<	4C	L	5C	\	6C	l	7C	|
0D	**CR**	1D	**GS**	2D	-	3D	=	4D	M	5D	]	6D	m	7D	}
0E	**SO**	1E	**RS**	2E	.	3E	>	4E	N	5E	^	6E	n	7E	~
0F	**SI**	1F	**US**	2F	/	3F	?	4F	O	5F	_	6F	o	7F	**DEL**

- Special "null" character often used to "terminate" a string (we will see this again)

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How do we **display** a number?

- Suppose there is an unsigned 8-bit number that we want to show on a character display as a 3-digit decimal number
  - We need to put the three ASCII codes (for the decimal digits) into the display's memory so that the decimal number appears on the screen
- How do we do it?

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Repeated Subtraction Algorithm

```
hundreds = tens = ones = 0
while (num > 100)
        hundreds = hundreds + 1
        num = num – 100
while (num > 10)
        tens = tens + 1
        num = num – 10
ones = num
```

num	hundreds	tens	ones
123			

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Division/Modulus Algorithm

- In any binary division (software or hardware), we get <u>both</u> the quotient and the remainder
  - Quotient: B / 10 Modulus: B % 10
- Algorithm

	num	hundreds	tens	ones
ones = num % 10	123			
num = num / 10				
tens = num % 10				
hundreds = num / 10				

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Digit Values to Characters

- After applying one of the algorithms, we have three variables, each with the <u>value</u> of one of the decimal digits
  - What would happen if we put those <u>values</u> into the display memory instead of the ASCII codes for the characters?
- How do we convert those values to the corresponding ASCII codes?

HEX	CHAR
30	0
31	1
32	2
33	3
34	4
35	5
36	6
37	7
38	8
39	9

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Wrapping Up

- Up Next:
  - Logic Functions
  - Truth Tables
  - Logic Gates
  - Combinational Circuits
- **Remember the homework!**
- **Remember your videos and reading**
  - **Including the video quiz!**
- Questions?