Digital Logic & Design

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Lecture 02

Recap

Last lecture discussion

- Decimal Number Systems
- Binary Number System
- Number System Conversion

Binary Arithmetic

- Binary Addition
- Binary Subtraction
- Binary Multiplication
- Binary Division

Binary Addition

- Four Basic rules for binary addition

1st digit	2nd digit	Sum	Carry
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

- Addition of multiple binary numbers

Binary Addition

Carry		1	10	1	
1st Number		1	0	1	1
2nd Number			1	1	0
3rd Number		1	0	0	0
4th Number				1	1
Result	1	1	1	0	0

Binary Subtraction

- Four Basic rules for binary subtraction

1st digit	2nd digit	Difference	Borrow
0	0	0	0
0	1	1	1
1	0	1	0
1	1	0	0

Binary Subtraction

Borrow			1		
1st Number		1	0	1	1
2nd Number			1	1	0
Result			1	0	1

Binary Multiplication

- Four Basic rules for binary multiplication

1st digit	2nd digit	Product
0	0	0
0	1	0
1	0	0
1	1	1

- Example of Binary Multiplication

Binary Multiplication

$$1101 \quad (13)$$
$$x \quad \underline{\ 101\ } \quad (5)$$

1st product term   1101

2nd product term   0000

3rd product term $\underline{1101}$

Product   1000001   (65)

Multiplication by shifting left

- Decimal 29 shifted left by one digit
- 290
- Shift left 1 digit is multiply by 10

- Binary 11101_2 (29) shifted left by one bit
- 111010_2 (58)
- Shift left 1 bit is multiply by 2

Binary Division

```
      10
101 | 1101
      101
      011
        000
      11
```

Division by shifting right

- Decimal 29 shifted right by one digit
- 2.9
- Shift left 1 digit is divide by 10

- Binary 11101_2 (29) shifted left by one bit
- 1110.1_2 (14.5)
- Shift left 1 bit is divide by 2

Signed and Unsigned Numbers

- Unsigned Binary Numbers
- Signed Binary Numbers
    - Most significant bit represents sign
    - 0 represents a positive number
    - 1 represents a negative number

2's Complement form

- 1's complement form
- 2's complement form

Binary number   01101   (13)

1's complement   10010

              +   1

2's complement   10011   (-13)

Addition and Subtraction with 2's Complement

0101	+5	0101	+5
0010	+2	1110	-2
0111	+7	0011	+3

1011	-5	1011	-5
1110	-2	0010	+2
1001	-7	1101	-3

Summary

- Binary to Decimal Conversion
  - Sum-of-Weights
  - Sum of non-zero terms
- Decimal to Binary Conversion
  - Sum-of-Weights (in reverse)
  - Repeated Division by 2

Summary

- Binary to Decimal fraction conversion
  - Sum-of-Weights
- Binary to Decimal fraction conversion
  - Repeated Multiplication by 2

Summary

- Binary Addition
- Binary Subtraction
- Binary Multiplication
  - Multiplication by shift left operation
- Binary Division
  - Division by shift right operation

Summary

- Unsigned Binary
- Signed Binary
  - Sign Bit
- 2's Complement
- 1's Complement
- Range of Binary Numbers

Lecture No. 2

Number Systems