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NUMBER SYSTEMS SUPPLEMENTARY NOTES

Acknowledgement

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Policies for students

- These contents are only used for students PERSONALLY.
- Students are NOT allowed to modify or deliver these contents to anywhere or anyone for any purpose.

Recording of modifications

- Currently, there are no modification on these contents.

NUMBER SYSTEMS SUPPLEMENTARY NOTES

- Complements
- Floating-point Numbers

COMPLEMENTS (1/3)

- "Find the complement of a number" or "complement a number" is the short way of saying… "find the negated value in that complement system".
- For example, the two questions below are equivalent.
  - [4-bit] Find/get the 1's complement of 0110
    (or, 1's complement this value: 0110)
    Answer: 1001.
  - [4-bit] If x is 0110_{1s}, what is -x in 1's complement form?
    Answer: 1001_{1s}
- So, "find the 1's complement of 0110" is <u>not</u> asking for "how is 0110 represented in 1's complement". See next two slides for more examples.

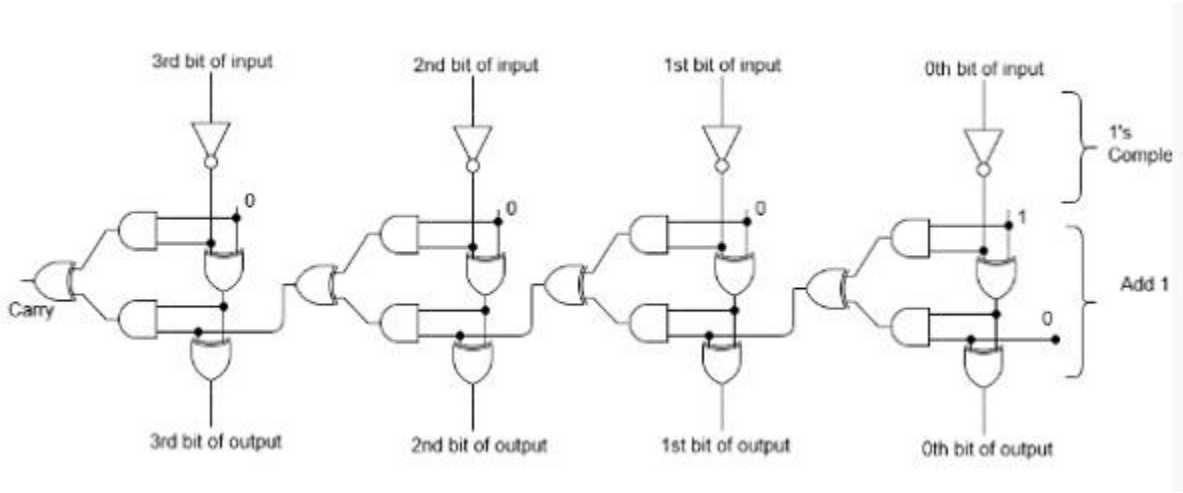
COMPLEMENTS (2/3)

- More examples:
  - [8-bit] Find the 1's complement of 101.
    Answer: 11111010
  - [8-bit] Find the 1's complement of 11001000.
    Answer: 00110111
  - [8-bit] How is 101_2 (5_{10}) represented in 1's complement?
    Answer: 00000101_{1s}
  - [8-bit] How is -101_2 (-5_{10}) represented in 1's complement?
    Answer: 11111010_{1s}
  - [8-bit] Find the 2's complement of 111000.
    Answer: 11001000
  - [12-bit] Find the 2's complement of 101.
    Answer: 111111111011

Difinition

- Generally, there are two types of complement of Binary number: 1’s complement and 2’s complement.
- To get 1’s complement of a binary number, simply invert the given number. For example, 1’s complement of binary number 110010 is 001101.
- To get 2’s complement of binary number is 1’s complement of given number plus 1 to the least significant bit (LSB). For example 2’s complement of binary number 10010 is (01101) + 1 = 01110.

Ligical circuit of 2’s complement



COMPLEMENTS (3/3)

- More examples:
  - [8-bit] What is 111_2 (7_{10}) in 2's complement form?
    Answer: 00000111
  - [8-bit] What is -111_2 (-7_{10}) in 2's complement form?
    Answer: 11111001
  - [10-bit] What is 14_{10} in 1's complement form?
    Answer: $(0000001110)_{1s}$
  - [10-bit] What is -14_{10} in 2's complement form?
    Answer: $(1111110010)_{2s}$

FLOATING-POINT NUMBERS (1/2)

- Assume a 10-bit floating-point scheme with: 1-bit sign, 5-bit normalised mantissa, and 4-bit exponent.
- What is this value: 1 11000 1001 ?
- Sign bit is 1, so value is negative.
- Mantissa is 0.11000_2, or 0.75_{10}
- What about exponent 1001?
  - If exponent is unsigned, then exponent = 9
  - If exponent is signed, and sign-and-magnitude is used, then exponent = -1
  - If exponent is signed, and 1's complement is used, then exponent = -6
  - If exponent is signed, and 2's complement is used, then exponent = -7

FLOATING-POINT NUMBERS (2/2)

- Therefore, **1 11000 1001**
  - If exponent is unsigned, then value is $-0.11_2 \times 2^9$, or -110000000_2, or -384_{10}.
  - If exponent is in sign-and-magnitude, then value is $-0.11_2 \times 2^{-1}$, or -0.011_2, or 0.375_{10}.
  - If exponent is in 1's complement form, then value is $-0.11_2 \times 2^{-6}$, or -0.00000011_2.
  - If exponent is in 2's complement form, then value is $-0.11_2 \times 2^{-7}$, or -0.000000011_2.

Q&A