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FACULTY OF ENGINEERING & TECHNOLOGY

CSPS-106 Computer Organization

Lecture-12

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OUTLINE

- REAL NUMBERS
- FLOATING POINT
- EXPRESSIBLE NUMBERS
- IEEE 754 AND FORMAT
- FLOATING POINT MULTIPLICATION /DIVISION

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REAL NUMBERS

- Numbers with fractions
- Could be done in pure binary
  - $1001.1010 = 2^4 + 2^0 + 2^{-1} + 2^{-3} = 9.625$
- Where is the binary point?
- Fixed?
  - Very limited
- Moving?
  - How do you show where it is?

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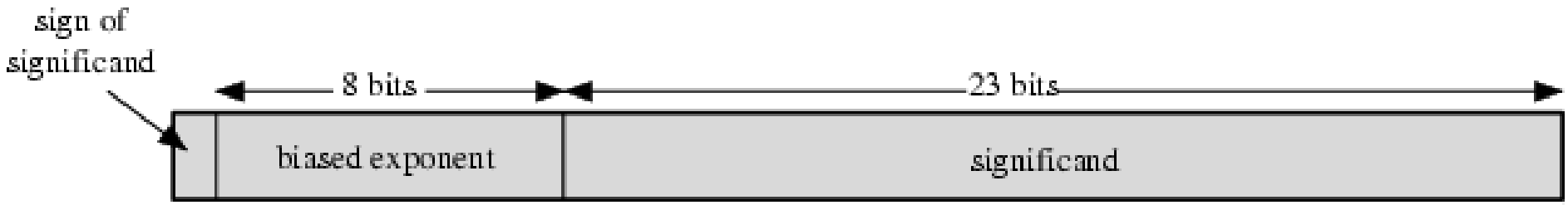
FLOATING POINT

- +/- .significand x $2^{exponent}$
- Misnomer
- Point is actually fixed between sign bit and body of mantissa
- Exponent indicates place value (point position)

FLOATING POINT EXAMPLES



(a) Format

$$
\begin{aligned}
1.1010001 \times 2^{10100} &= 0\ 10010011\ 10100010000000000000000 = 1.638125 \times 2^{20} \\
-1.1010001 \times 2^{10100} &= 1\ 10010011\ 10100010000000000000000 = -1.638125 \times 2^{20} \\
1.1010001 \times 2^{-10100} &= 0\ 01101011\ 10100010000000000000000 = 1.638125 \times 2^{-20} \\
-1.1010001 \times 2^{-10100} &= 1\ 01101011\ 10100010000000000000000 = -1.638125 \times 2^{-20}
\end{aligned}
$$

(b) Examples

SIGNS FOR FLOATING POINT

- Mantissa is stored in 2s compliment
- Exponent is in excess or biased notation
  - e.g. Excess (bias) 128 means
  - 8 bit exponent field
  - Pure value range 0-255
  - Subtract 128 to get correct value
  - Range -128 to +127

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NORMALIZATION

- FP numbers are usually normalized
- i.e. exponent is adjusted so that leading bit (MSB) of mantissa is 1
- Since it is always 1 there is no need to store it
- (c.f. Scientific notation where numbers are normalized to give a single digit before the decimal point
- e.g. 3.123×10^3)

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FP RANGES

- For a 32 bit number
  - 8 bit exponent
  - +/- $2^{256} \approx 1.5 \times 10^{77}$
- Accuracy
  - The effect of changing lsb of mantissa
  - 23 bit mantissa $2^{-23} \approx 1.2 \times 10^{-7}$
  - About 6 decimal places

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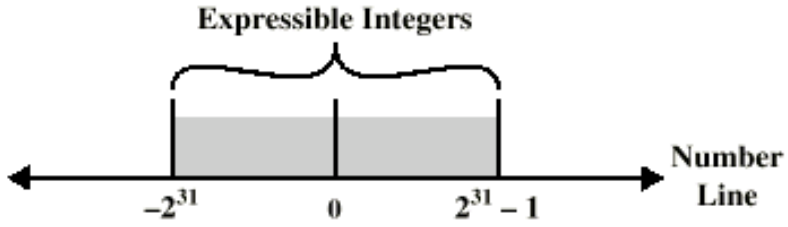
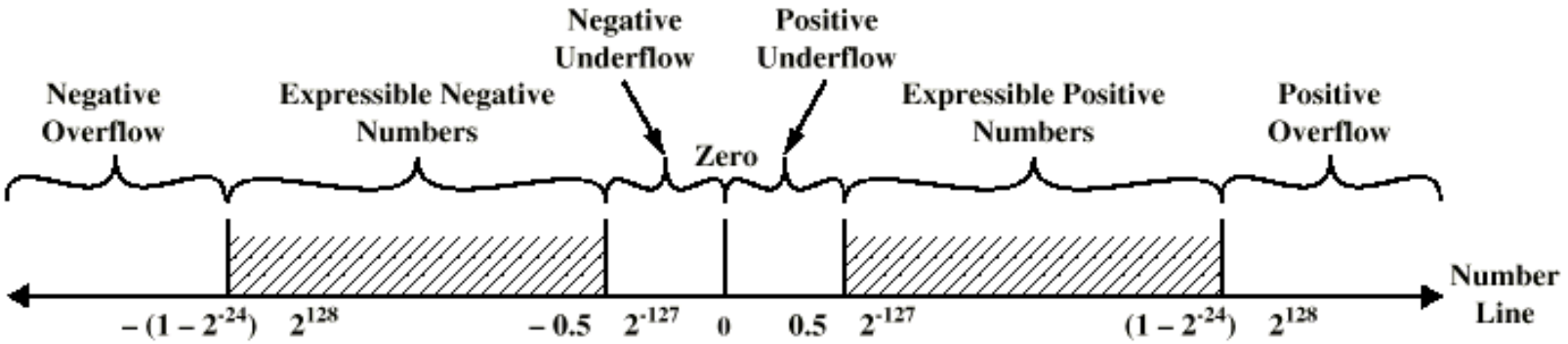
EXPRESSIBLE NUMBERS



(a) Twos Complement Integers

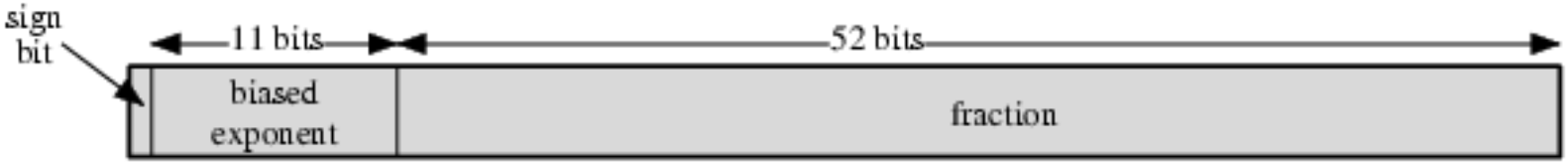


(b) Floating-Point Numbers

IEEE 754 AND FORMAT

- Standard for floating point storage
- 32 and 64 bit standards
- 8 and 11 bit exponent respectively
- Extended formats (both mantissa and exponent) for intermediate results

(a) Single format

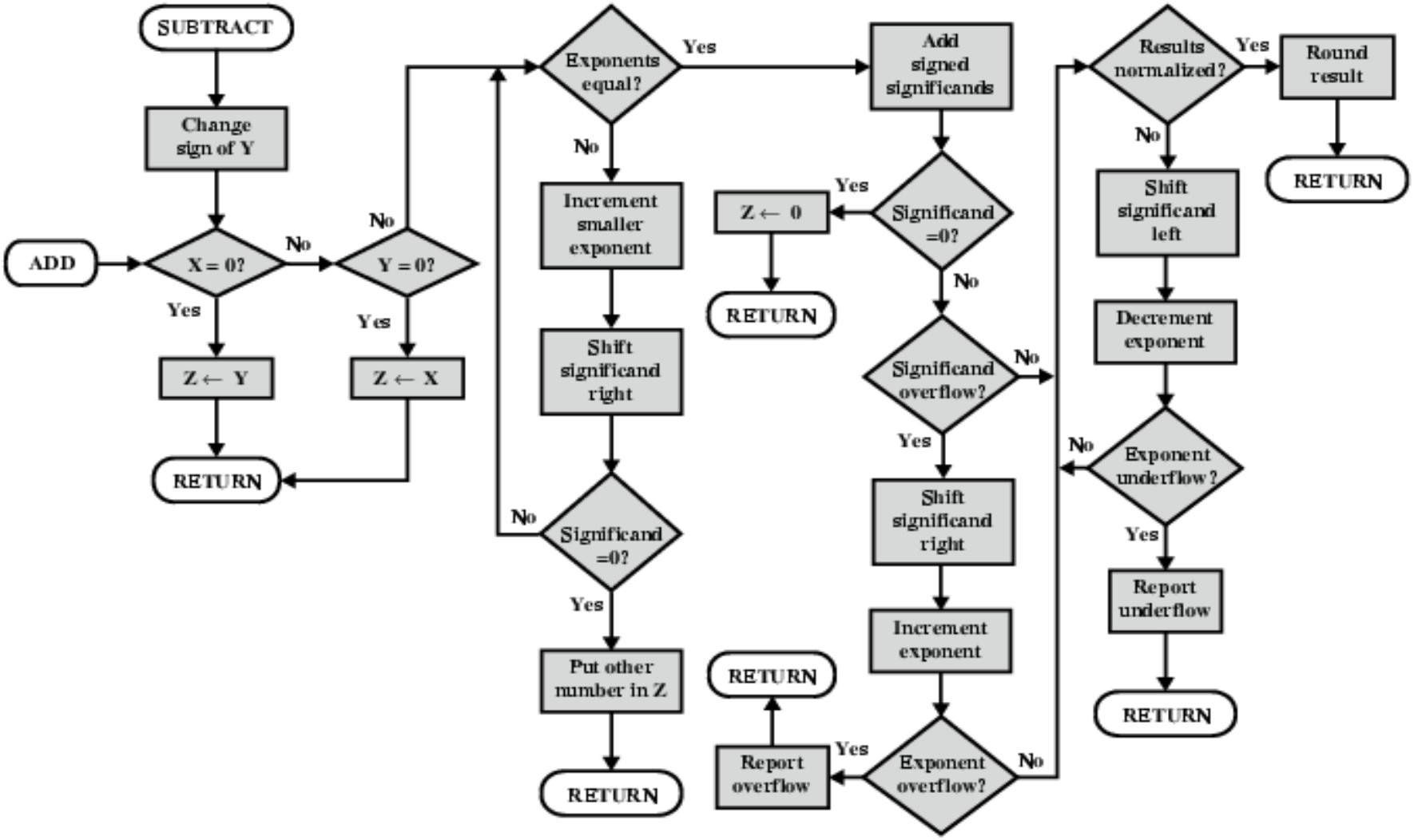


(b) Double format

FP ARITHMETIC +/-

- Check for zeros
- Align significands (adjusting exponents)
- Add or subtract significands
- Normalize result

FP ADDITION & SUBTRACTION FLOWCHART



FP ARITHMETIC X/÷

- Check for zero
- Add/subtract exponents
- Multiply/divide significands (watch sign)
- Normalize
- Round
- All intermediate results should be in double length storage

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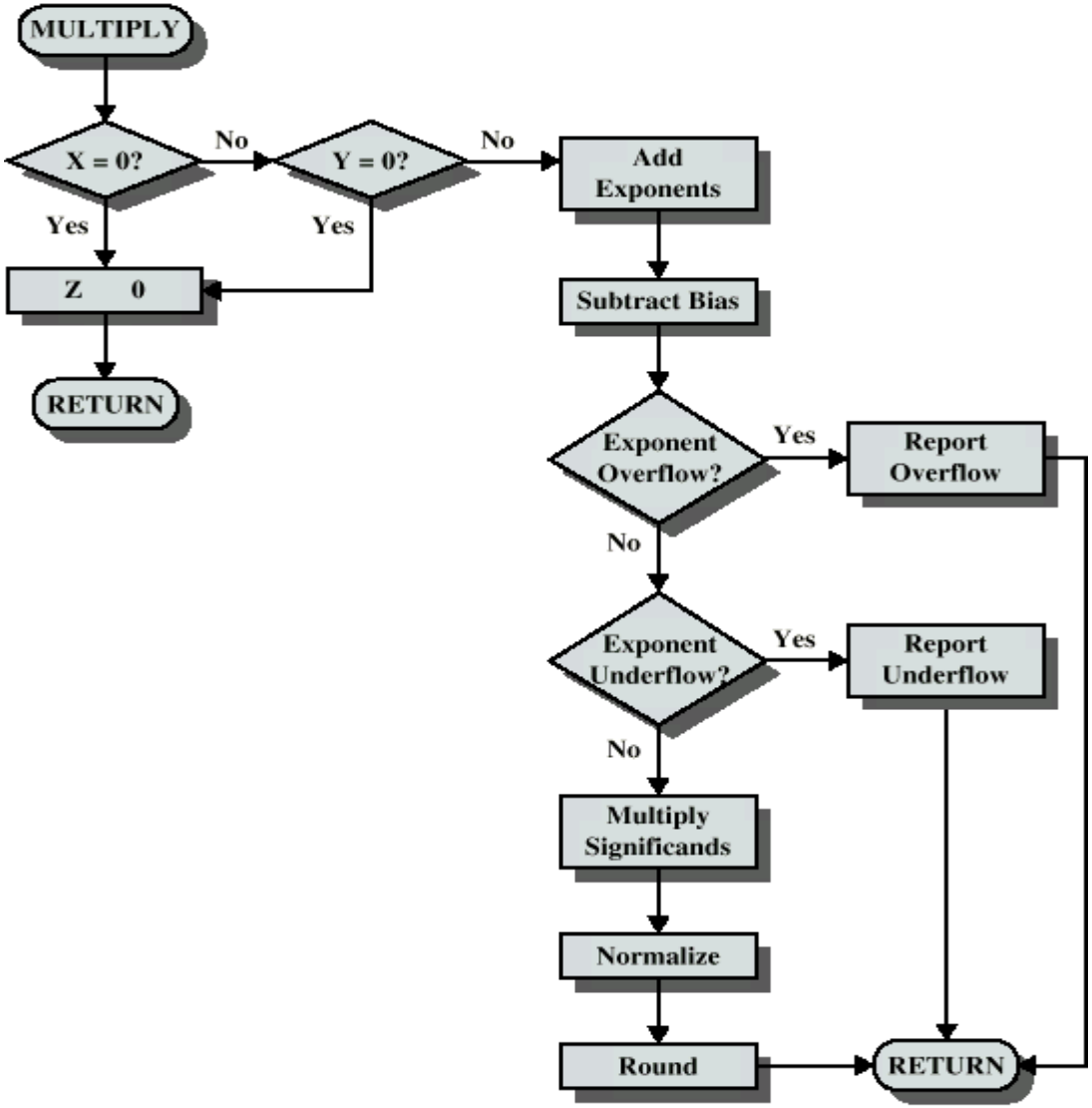
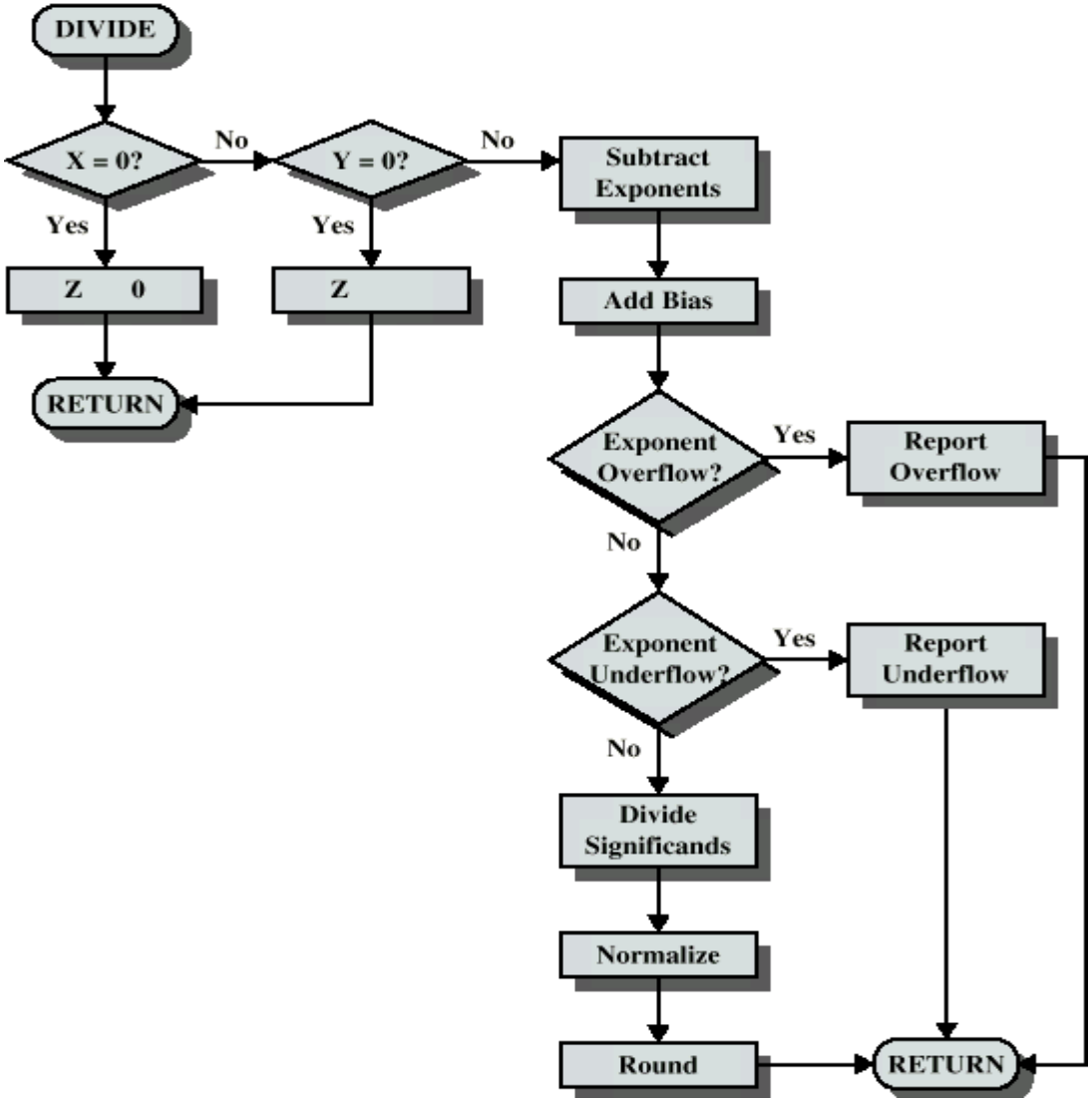
FLOATING POINT MULTIPLICATION



FLOATING POINT DIVISION



Multiple Choice Question

MUTIPLE CHOICE QUESTIONS:

Sr no	Question	Option A	Option B	OptionC	OptionD
1	The Hamming distance between 100 and 001 is_	1	2	3	4
2	Hamming distance between equal codewords is	0	1	2	3
3	block coding, if k =2 and n =3, we have codewords	1	2	3	4
4	codes are special linear block codes with one extra property. If a codeword is rotated, the result is another codeword	Non-linear	Convolution	Cyclic	none of the above
5	simple parity-check code can detect errors	even a number of	two	no errors	an odds number of

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REFERENCES

- http://www.engppt.com/search/label/Computer%20Organization%20and%20Architecture
- http://www.engppt.com/search/label/Computer%20Architecture%20ppt