Федеральное государственное автономное образовательное учреждение высшего образования «Национальный исследовательский университет ИТМО»

Факультет программной инженерии и компьютерной техники

Основы дискретной математики

Домашняя работа №6

Сложение чисел с плавающей запятой

Вариант №116

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Санкт-Петербург 2023

|  |  |  |
| --- | --- | --- |
| **№** | **A** | **B** |
| **116** | 21,67 | 18,43 |

# Задание. Заданные числа А и В представить в форме с плавающей запятой в разрядных сетках форматов Ф1 и Ф2 с укороченной мантиссой (12 двоичных разрядов).

1. Ф1:

A = (21,67)10 = (15,AB851EB851E)16 = (0,15B)16 × 162

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 1 |
| 0 | 1 |  |  |  |  |  | 7 | 8 |  |  |  |  |  |  |  |  |  |  | 19 |

B = (18,43)10 = (12,6E147A)16 = (0,127)16 × 162

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 1 |
| 0 | 1 |  |  |  |  |  | 7 | 8 |  |  |  |  |  |  |  |  |  |  | 19 |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| − XA | = | 1 | 0 | 0 | 0 | 0 | 1 | 0 |
| XB | = | 1 | 0 | 0 | 0 | 0 | 1 | 0 |
| (XA − XB) | = | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

(XA − XB)= 0; XC = XB = 2

А) A > 0, B > 0

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| MA | =  + | . | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 1 |
| MB | = | . | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 1 |
| MC | = | . | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 0 | 1 |  |  |  |  |  | 7 | 8 |  |  |  |  |  |  |  |  |  |  | 19 |

Результат сложения нормализован.

C

*С*\* = М*С* × 16Р*с* = (0,282)16 × 162 = (28,2)16 = 40,125.

Δ*С* = *С*Т – *С*\* = 40,1 – 40,125 = −0,025,

δ*С* = 100% = 100% = 0,06234%.

Погрешность полученного результата можно объяснить следующими факторами:

* Неточным представлением операндов

Б) A > 0, B < 0

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| MA | = | . | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 1 |
| MB | = | .  − | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 1 |
| MC | = | . | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 |

Результат вычитания денормализован вправо.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 1 |  |  |  |  |  | 7 | 8 |  |  |  |  |  |  |  |  |  |  | 19 |

Т.к. выполнен сдвиг мантиссы влево, характеристику результата нужно уменьшить на 1 (ХC = ХC − 1 = 1).

C

*С*\* = М*С* × 16Р*с* = (0,340)16 × 161 = (3,40)16 = 3,25.

Δ*С* = *С*Т – *С*\* = 3,24 – 3,25 = −0,01,

δ*С* = 100% = 100% = 0,30864%.

Погрешность полученного результата можно объяснить следующими факторами:

* Неточным представлением операндов;
* Потерей значащих разрядов мантиссы результата при его нормализации сдвигом мантиссы.

В) A < 0, B > 0

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| MB | = | . | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 1 |
| MA | = | .  − | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 1 |
| MC | = | . | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 |

Результат вычитания денормализован вправо и представлен в дополнительном коде.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 1 |  |  |  |  |  | 7 | 8 |  |  |  |  |  |  |  |  |  |  | 19 |

Т.к. выполнен сдвиг мантиссы влево, характеристику результата нужно уменьшить на 1 (ХC = ХC − 1 = 1).

C

*С*\* = М*С* × 16Р*с* = (−0,340)16 × 161 = (−3,40)16 = −3,25.

Δ*С* = *С*Т – *С*\* = −3,24 – (−3,25) = 0,01,

δ*С* = 100% = 100% = 0,30864%.

Погрешность полученного результата можно объяснить следующими факторами:

* Неточным представлением операндов;
* Потерей значащих разрядов мантиссы результата при его нормализации сдвигом мантиссы.

1. Ф2:

A = (21,67)10 = (15,AB851F)16 = (10101,1101010111000010100011111)2 = (0,10101101010111000010100011111)2 × 25

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 0 |
| 19 | 18 |  |  |  |  |  | 11 | 10 |  |  |  |  |  |  |  |  |  | 0 |

B = (18,43)10 = (12,6E147B)16 = (10010,01101110000101)2 = (0,1001001101110000101)2 × 25

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 1 |
| 19 | 18 |  |  |  |  |  | 11 | 10 |  |  |  |  |  |  |  |  |  | 0 |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| − XA | = | 1 | 0 | 0 | 0 | 1 | 0 | 1 |
| XB | = | 1 | 0 | 0 | 0 | 1 | 0 | 1 |
| (XA − XB) | = | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

(XA − XB)= 0; XC = XB = 5

А) A > 0, B > 0

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| MA | =  + | . | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 0 |
| MB | = | . | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 1 |
| MC | = | 1. | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 |

Результат сложения денормализован влево.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| 19 | 18 |  |  |  |  |  | 11 | 10 |  |  |  |  |  |  |  |  |  | 0 |

Т.к. выполнен сдвиг мантиссы влево, то характеристику результата нужно увеличить на 1 (ХС = ХС +1 = 6).

C

*С*\* = М*С* × 2Р*с* = (0,10100000011)2 × 26 = (101000,00011)2 = 40,09375.

Δ*С* = *С*Т – *С*\* = 40,1 – 40,09375 = 0,00625,

δ*С* = 100% = 100% = 0,01558603%.

Погрешность полученного результата можно объяснить следующими факторами:

* Неточным представлением операндов;
* Потерей значащих разрядов мантиссы результата при его нормализации сдвигом мантиссы.

Б) A > 0, B < 0

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| MA | =  − | . | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 0 |
| MB | = | . | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 1 |
| MC | = | . | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 |

Результат вычитания денормализован вправо.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 |
| 19 | 18 |  |  |  |  |  | 11 | 10 |  |  |  |  |  |  |  |  |  | 0 |

Т.к. выполнен сдвиг мантиссы влево, характеристику результата нужно уменьшить на 3 (ХC = ХC − 3 = 2).

C

*С*\* = М*С* × 2Р*с* = (0,110011111)2 × 22 = (11,0011111)2 = 3,2421875.

Δ*С* = *С*Т – *С*\* = 3,24 – 3,2421875 = –0,0021875,

δ*С* = 100% = 100% = 0,00067515 %.

Погрешность полученного результата можно объяснить следующими факторами:

* Неточным представлением операндов;
* Потерей значащих разрядов мантиссы результата при его нормализации сдвигом мантиссы.

В) A < 0, B > 0

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| MB | =  − | . | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 1 |
| MA | = | . | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 0 |
| MC | = | . | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 |

Результат вычитания денормализован вправо и представлен в дополнительном коде.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 |
| 19 | 18 |  |  |  |  |  | 11 | 10 |  |  |  |  |  |  |  |  |  | 0 |

Т.к. выполнен сдвиг мантиссы влево, характеристику результата нужно уменьшить на 3 (ХC = ХC − 3 = 2).

C

*С*\* = М*С* × 2Р*с* = −(0,110011111)2 × 22 = −(11,0011111)2 = −3,2421875.

Δ*С* = *С*Т – *С*\* = −3,24 – (−3,2421875) = 0,0021875,

δ*С* = 100% = 100% = 0,00067515 %.

Погрешность полученного результата можно объяснить следующими факторами:

* Неточным представлением операндов;
* Потерей значащих разрядов мантиссы результата при его нормализации сдвигом мантиссы.