Chapter 02. 데이터

# 정수형

# int

| Type specifier | Equivalent type | Width in bits by data model | | | | |
|---|---|---|---|---|---|---|
| | | C++ standard | LP32 | ILP32 | LLP64 | LP64 |
| short | short int | at least 16 | 16 | 16 | 16 | 16 |
| short int | | | | | | |
| signed short | | | | | | |
| signed short int | | | | | | |
| unsigned short | unsigned short int | | | | | |
| unsigned short int | | | | | | |
| int | int | at least 16 | 16 | 32 | 32 | 32 |
| signed | | | | | | |
| signed int | | | | | | |
| unsigned | unsigned int | | | | | |
| unsigned int | | | | | | |

# int

| Type specifier | Equivalent type | Width in bits by data model | | | | |
|---|---|---|---|---|---|---|
| | | C++ standard | LP32 | ILP32 | LLP64 | LP64 |
| long | long int | at least 32 | 32 | 32 | 32 | 64 |
| long int | | | | | | |
| signed long | | | | | | |
| signed long int | | | | | | |
| unsigned long | unsigned long int | | | | | |
| unsigned long int | | | | | | |
| long long | long long int (C++11) | at least 64 | 64 | 64 | 64 | 64 |
| long long int | | | | | | |
| signed long long | | | | | | |
| signed long long int | | | | | | |
| unsigned long long | unsigned long long int (C++11) | | | | | |
| unsigned long long int | | | | | | |

# int

| | | | |
|---|---|---|---|
| 32 bit systems | LP32 | 2/4/4 | Win16 API |
| | ILP32 | 4/4/4 | Win32 API<br>Unix and Unix-like systems<br>(Linux, Mac OS X) |
| 64 bit systems | LLP64 | 4/4/8 | Win64 API |
| | LP64 | 4/8/8 | Unix and Unix-like systems<br>(Linux, Mac OS X) |

# Binary(이진법)

$0 = 0_{(2)}$

$1 = 1_{(2)}$

$2 = 10_{(2)}$

$3 = 11_{(2)}$

$4 = 100_{(2)}$

$8 = 1000_{(2)}$

$16 = 10000_{(2)}$

$32 = 100000_{(2)}$

$64 = 1000000_{(2)}$

$100 = 1100100_{(2)}$

$128 = 10000000_{(2)}$

# Binary(이진법)

$100 = 1100100_{(2)}$

| Decimal | | |
|---|---|---|
| $10^2$ | $10^1$ | $10^0$ |
| 1 | 0 | 0 |

$100 = 1 * 10^2 + 0 * 10^1 + 0 * 10^0$

| Binary | | | | | | |
|---|---|---|---|---|---|---|
| $2^6$ | $2^5$ | $2^4$ | $2^3$ | $2^2$ | $2^1$ | $2^0$ |
| 1 | 1 | 0 | 0 | 1 | 0 | 0 |

$1100100_{(2)} = 1 * 2^6 + 1 * 2^5 + 0 * 2^4 + 0 * 2^3 + 1 * 2^2 + 0 * 2^1 + 0 * 2^0$

# unsigned(부호 없는)

```
uint8_t num0 = 1; // base 10
```

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |

```
uint16_t num1 = 020; // base 8
// 16 = 2 * 8^1 + 0 * 8^0
// 16 = 1 * 2^4 + 0 * 2^3 + 0 * 2^2 + 0 * 2^1 + 0 * 2^0
```

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |

```
uint32_t num2 = 0xff; // base 16
// 255 = 15 * 16^1 + 15 * 16^0,
// 255 = 1 * 2^7 + 1 * 2^6 + 1 * 2^5 + 1 * 2^4 + 1 * 2^3 + 1 * 2^2 + 1 + 2^1 + 1 + 2^0 * 1
```

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

```
uint32_t num3 = 0b1010; // base 2
// 9 = 1 * 2^3 + 0 * 2^2 + 1 * 2^1 + 0 * 2^0
```

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |

# unsigned(부호 없는)

8 bit max value = 255

$255 = 2^7 + 2^6 + 2^5 + 2^4 + 2^3 + 2^2 + 2^1 + 2^0$

$255 = 2^8 - 1$

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

16 bit max value = 65535

$65535 = 2^{16} - 1$

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

32 bit max value = 4294967295

$4294967295 = 2^{32} - 1$

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

# unsigned(부호 없는)

덧셈

6 + 7 = 13

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 |
| 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 |

$6 = 2^2 + 2^1$

$7 = 2^2 + 2^1 + 2^0$

$13 = 2^3 + 2^2 + 2^0$

# signed(부호 있는)


Most Significant Bit(MSB)
Sign Bit

# signed(부호 있는)

~~Simple method~~

-1

| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
|---|---|---|---|---|---|---|---|

-0 ??

| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
|---|---|---|---|---|---|---|---|

# signed(부호 있는)

2의 보수
- 각 비트 반전
- 1을 더함

예시)

$3 = 2^1 + 2^0$

| 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
|---|---|---|---|---|---|---|---|

각 비트 반전

Sign Bit

| 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
|---|---|---|---|---|---|---|---|

1 더하기

| 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 |
|---|---|---|---|---|---|---|---|

-> -3

# signed(부호 있는)

| 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 |
|---|---|---|---|---|---|---|---|

각 비트 반전

| 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
|---|---|---|---|---|---|---|---|

1 더하기

| 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
|---|---|---|---|---|---|---|---|

-> 3 = $2^1$ + $2^1$

# signed(부호 있는)

8 bit max value = 127

$127 = 2^6 + 2^5 + 2^4 + 2^3 + 2^2 + 2^1 + 2^0$

$127 = 2^7 - 1$

| 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
|---|---|---|---|---|---|---|---|

16 bit max value = 32767

$32767 = 2^{15} - 1$

| 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

32 bit max value = 2147483647

$2147483647 = 2^{31} - 1$

| 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

# signed(부호 있는)

8 bit min value = -128

| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
|---|---|---|---|---|---|---|---|

16 bit min value = -32768

| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

32 bit min value = -2147483648

| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

# signed(부호 있는)

덧셈

-6 + (-7) = -13

6, 7, 13

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 |
| 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 |

-6(보수), -7(보수), -13(보수)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 1 | 0 | 1 | 0 |
| 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 |
| 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 |

# signed(부호 있는)

덧셈(뺄셈)

6 - 7 = -1

6 + (-7) = -1

6, 7, 1

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |

6, -7(보수), -1(보수)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

# signed(부호 있는)

덧셈(뺄셈)

6 - 5 = 1

6 + (-5) = 1

6, 5, 1

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |

6, -5(보수), 1

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |

# Overflow

표현할 수 있는 최대값보다 더 커지는 상태

# Overflow

## Unsigned

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 255 + 1 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | = 0 |

# Overflow

## Signed

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 127 + 1 |
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | = -128 |

아래의 경우는 Overflow는 아님

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | -1 + 1 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | = 0 |

# Underflow

표현할 수 있는 최저값보다 더 적어지는 상태

# Underflow

## Unsigned

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 + (-1) |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | = 255 |

# Underflow

## Signed

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

-128 + (-1)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

= 127