Cheatography

# Signed Number Binary Representation Cheat Sheet

by [deleted] via cheatography.com/26304/cs/8570/

## Abbreviations and Notations

- LSB: Least Significant Bit (right-most bit)
- MSB: Most Significant Bit (left-most bit)
- SaM: Sign-and-Magnitude representation
- OsC: One's Complement representation
- TsC: Two's Complement representation
- `b`: a single bit
- `B_x`: set of bits representing number `x` base `10`, i.e. `B_x={b_i}, i=[0,N-1]`. Q : in a 4-bit register, `B_x=0101` for `x=5`
- Unless specified otherwise, we will use throughout 8-bit (1 byte) registers to represent integers => ranges are `[0,255]` for unsigned `int`s and `[-127, 127]` for signed `int`s.

## Types of Number representation

- Mainly: SaM, OsC, TsC, excess-`K`, Base-`2`
- TsC most widely used. Here, only SaM, OsC and TsC are coverved.
- For SaM/OsC/TsC, `B_x` for `x>0` is the same for all representations (this is not the case for excess-`K` and Base-`2`) => half the full range is always `B_[0, 127]=[ 000 0000, 01111111]`.
- `-x` will then depend on choice of representation.

## SaM

MSB directly represents the sign. `0` is for positive integers, `1` is for negative integers. Remaining bits are for magnitude

Q: `x = 43` has `B_x = 00101011` => `x = -43` has `B_x = 10101011`

⚠ 2 representations for `0` (`00000000` (`0`) and `10000000` (`-0`))

## OsC

For `x>0`, **`-x` represented by `B_(-x) = ~B_x`**

Q `x = 43` has `B_x = 00101011` => `x = -43` has `B_x = 11010100`

⚠ 2 representations for `0` (`B_0 = 00000000` and `B_(-0) = ~B_0 = 11111111`). In fact `B_x + B_(-x) = B_(-0)`

⚠ **Sometimes** imposes and end-around carry/borrow in addition/subtraction (in a `4`-bit register, try `7-3`, **`7+(-3)`**, `(-7)+3`, **`3-7`**, with corresponding OsC bit representation). **These do not occur in TsC arithmetic**

ℹ For `x>0` with representation `B_x`, `B_(-x) = B_x` as per OsC definition `<=> B_(-x) = B_0 - B_x`

## References

- Signed number Representation: Wikipedia
- Two's complement: Wikipedia
- Binary subtraction: YouTube

By **[deleted]**
cheatography.com/deleted-26304/

Not published yet.
Last updated 8th July, 2016.


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