Using excess notation to represent numbers

When using two's complement notation to represent a number, an N bit binary number can represent 2^N numbers ranging from $-(2^N/2)$ to $+(2^N/2 - 1)$. Zero is located at the middle of the range and for an 8 bit number, is represented by 00000000_2. The MSB of the number is used to represent the sign of the number, indicating a positive number when cleared and a negative number when set.

Generalising the concept, zero may not be located at the middle of the range and a bias number is used to represent it. Under this representation:

- Any binary number greater than the bias number is considered to be positive
- Any binary number smaller than the bias number, is considered to be negative
- Zero is represented by the bias number
- For 8 bits numbers, the negative of the bias number is represented by 00000000_2

This approach is known as excess notation representation of numbers.

Example:

3 bits excess notation (excess 4 notation)	111_2	3
	110_2	2
	101_2	1
	100_2	0
	011_2	-1
	010_2	-2
	001_2	-3
	000_2	-4

4 bits excess notation (excess 8 notation)	1111_2	7
	1110_2	6
	1101_2	5
	1100_2	4
	1011_2	3
	1010_2	2
	1001_2	1
	1000_2	0
	0111_2	-1
	0110_2	-2
	0101_2	-3
	0100_2	-4
	0011_2	-5
	0010_2	-6
	0001_2	-7
	0000_2	-8

Under this notation:

- inverting all bits of 0 yields -1
- positive numbers have their MSB set
- to calculate the binary representation of a positive number, add the number to the bias number (representing zero) and then convert the result to a binary number
- to calculate the binary representation of a negative number, subtract the absolute value of the number from the bias number and then convert the result to a binary number
- the binary addition and subtraction procedures mentioned before, cannot be applied in this representation

Examples:

1. Calculate 3 using excess 4 notation:
   - Excess 4 notation means that the bias number is equal to 8
   - Calculate 3 + 8 = 11
   - Convert 11 to binary: $11_{10} = 1011_2$
2. Calculate -2 using excess 3 notation:
   - Excess 3 notation means that the bias number is equal to 4
   - Calculate 4 – 2 = 2
   - Convert 2 to binary: $2_{10} = 10_2$

Use:
Excess notation is used to represent the exponent part of floating-point numbers. 8-bits excess-127 is used in single-precision (32-bit) numbers and 11-bits excess-1023 is used in double precision (64-bit) numbers.