پرارزش MSB

کم ارزش LSB

$2^7=128$	$2^6=64$	$2^5=32$	$2^4=16$	$2^3=8$	$2^2=4$	$2^1=2$	$2^0=1$
0	0	1	0	0	0	1	1
2^3	2^2	2^1	2^0	2^3	2^2	2^1	2^0

A =

$0\times8+0\times4+1\times2+0\times0=2$ | $0\times8+0\times4+0\times2+1\times1=3$

$(dec)_{10} \rightleftarrows (bin)_2$

A=35

$$\begin{array}{r|l} 35 & 2 \\ 34 & 17 \;|\; 2 \\ \hline 1 & 16 \quad 8 \;|\; 2 \\ & 1 \quad 8 \quad 4 \;|\; 2 \\ & \quad 0 \quad 4 \quad 2 \;|\; 2 \\ & \quad\quad 0 \quad 2 \quad 1 \\ & \quad\quad\quad 0 \end{array}$$

$A=0\times128+0\times64+1\times32+0\times16+0\times8+0\times4+1\times2+1\times1$

$A=(35)_{10}$ $\quad A=0b00100011;$ $\quad (bin)_2$

$A=0x23;\quad (23)_{16}$

8	4	2	1	8	4	2	1
0	0	1	0	0	0	1	1

E → 14, 7

8	4	2	1	8	4	2	1
1	1	1	0	0	1	1	1

0xE7 →

0
1
2
3
4
5
6
7
8
9
A → 10
B → 11
C → 12
D → 13
E → 14
F → 15

$(35)_{10} \rightarrow (43)_8$

$$\begin{array}{r|l} 35 & 8 \\ 32 & 4 \\ \hline 3 & \end{array}$$

$A=043;$ ← octal

A=35

$A=035;$

$(35)_8 \rightarrow (29)_{10}$

کم ارزش : $8+4+2+1=15 \rightarrow 0 \rightarrow 15$

پرارزش : $128+64+32+16=240 \rightarrow 16 \rightarrow 240$

8bit=1Byte = $128+64+32+16+8+4+2+1=255$

$0 \rightarrow 2^8-1$ $\quad 0 \rightarrow 255$ (256) $\quad 2^8=256 \quad 0 \rightarrow 255$

a++;

a=255

a++; 256 → 0

سرریز overflow

$0 \xrightarrow{++} 1 \xrightarrow{++} 2 ---\xrightarrow{++} 254 \xrightarrow{++} 255 \xrightarrow{++} 0 \xrightarrow{++} 1$

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

Sign →

	S (بیت علامت)	2^1 (2)	2^0 (1)
−3	1	1	1
−2	1	1	0
−1	1	0	1
−0	1	0	0
+0	0	0	0
+1	0	0	1
+2	0	1	0
+3	0	1	1

Sign → S = 1 منفی, S = 0 مثبت

$$\begin{array}{r} +1 \\ +(-1) \\ \hline 0 \end{array} \qquad \begin{array}{r} 001 \\ +\;101 \\ \hline (110)_b = (-2)_d \end{array}$$

$$\begin{array}{r} +3 \\ +(-2) \\ \hline 1 \end{array} \qquad \begin{array}{r} 011 \\ 110 \\ \hline 1\,(001)_b = (+1)_d \end{array}$$

$$\begin{array}{r} +3 \\ +(-1) \\ \hline 2 \end{array} \qquad \begin{array}{r} 011 \\ 101 \\ \hline 1\,(000)_b \to (+0)_d \end{array}$$

! مشکل → ones complement +1 → مشکل رو → Twos complement

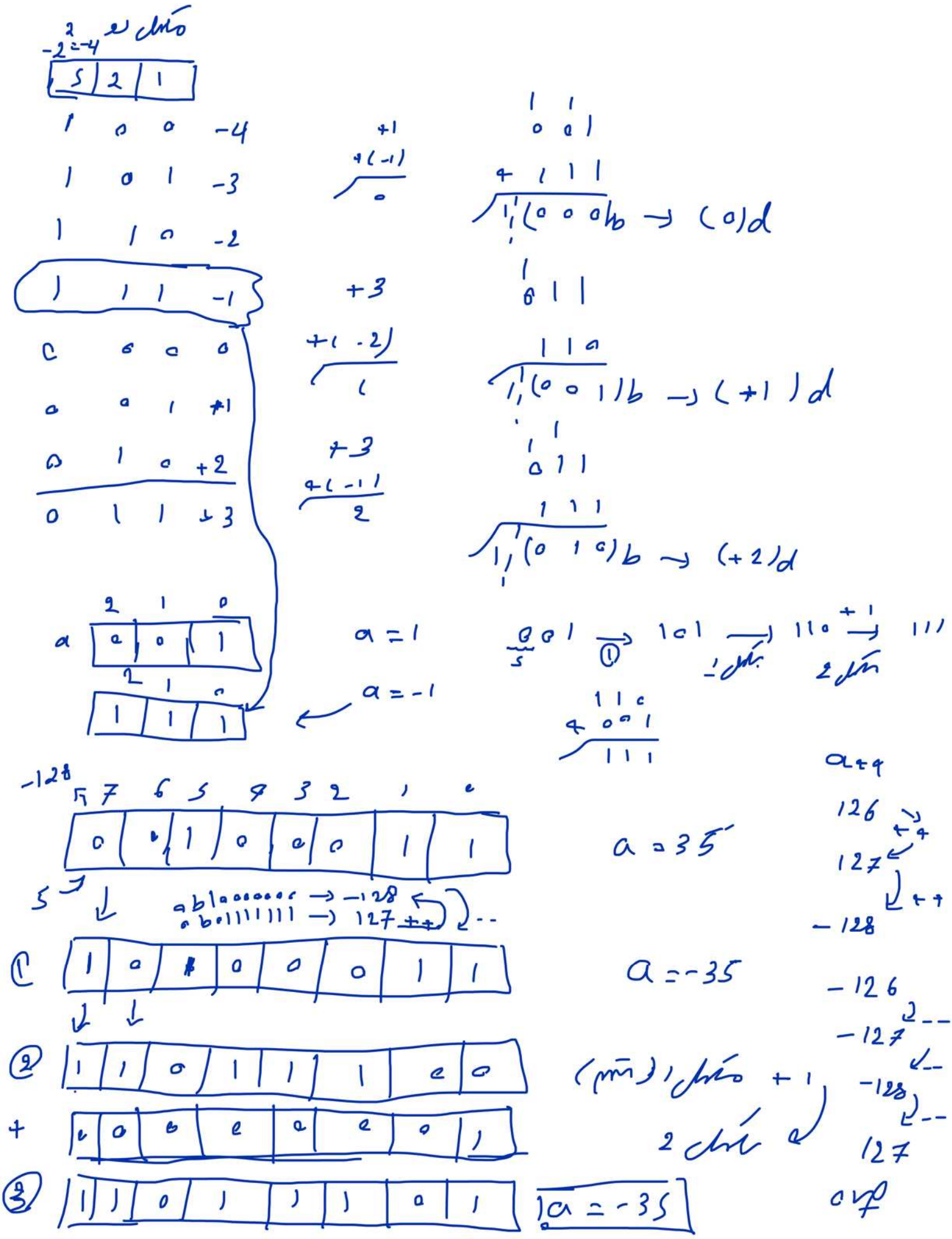
متمم

	S	2	1
−3	1	0	0
−2	1	0	1
−1	1	1	0
−0	1	1	1
+0	0	0	0
+1	0	0	1
+2	0	1	0
+3	0	1	1

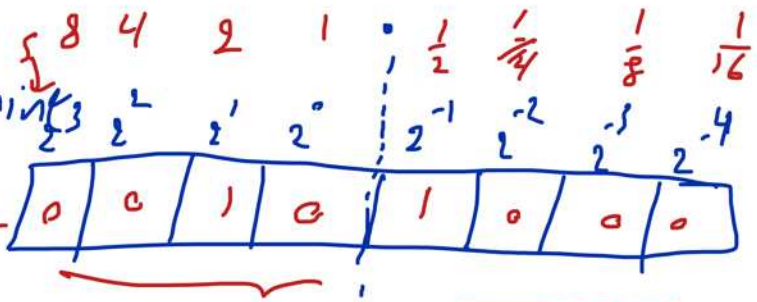
$$\begin{array}{r} +1 \\ +(-1) \\ \hline 0 \end{array} \qquad \begin{array}{r} 001 \\ +\;110 \\ \hline (111)_b \to (-0) \end{array}$$

$$\begin{array}{r} +3 \\ +(-2) \\ \hline 1 \end{array} \qquad \begin{array}{r} 011 \\ 101 \\ \hline 1\,(000)_b \to (+0) \end{array}$$

$$\begin{array}{r} +3 \\ +(-1) \\ \hline 2 \end{array} \qquad \begin{array}{r} 011 \\ +\;110 \\ \hline 1\,(001)_b \to (+1)_d \end{array}$$


2 số dư
-2^2 = -4
5 2 1
1 0 0 -4
1 0 1 -3
1 1 0 -2
1 1 1 -1
0 0 0 0
0 0 1 +1
0 1 0 +2
0 1 1 +3
+1
+(-1)
0
+3
+(-2)
1
+3
+(-1)
2
1 1
0 0 1
+ 1 1 1
1 (0 0 0)b → (0)d
1
0 1 1
1 1 a
1 (0 0 1)b → (+1)d
1 1
0 1 1
1 1 1
1 (0 1 0)b → (+2)d
2 1 0
a 0 1
a = 1
2 1 0
1 1 1
a = -1
001 → 101 → 110 → 111
5
① 1 số dư
2 số dư
1 1 0
+ 0 0 1
1 1 1
-128
7 6 5 4 3 2 1 0
0 1 1 0 0 0 1 1
a = 35
5
a b 1 0 0 0 0 0 0 0 → -128
a b 1 1 1 1 1 1 1 1 → 127 ++
--
① 1 0 0 0 0 0 1 1
a = -35
② 1 1 0 1 1 1 0 0
(phần) bù 2 + 1
+ 1 0 0 1 0 0 0 1
③ 1 1 0 1 1 1 0 1
a = -35
a++
126
127
++
-128
-126
--
-127
--
-128
--
127
ovf

fixed point



S=1 → 음
S=0 → 양

+ 2.5

range

accuracy

0×4 + 1×2 + 0×1 = 2

1×1/2 + 0×1/4 + 0×1/8 + 0×1/16 = 0.5

⇒ 2 + 0.5 = 2.5

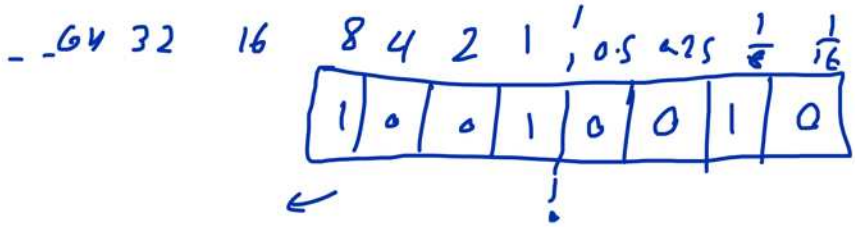
a = 2.5

2 | 2
2 | 1
0

x

0.5 × 2 = 1.

0 × 2 = 0 !



9.140625

9 | 2
8 4 | 2
1 4 2 | 2
2 1 | 2
0

1×8 + 0×4 + 0×2 + 1×1 = 9

0×0.5 + 0×0.25 + 1×0.125 + 0×0.0625 = 0.125

a = 9 + 0.125 = 9.125 !!

8bit fixed point !!

16bit

32bit

0.140625 × 2 = 0.28125

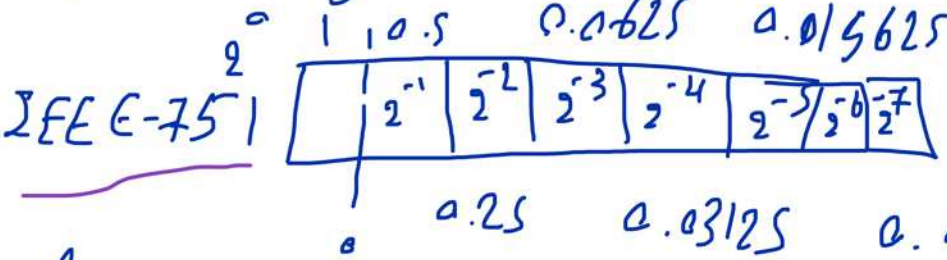
0.28125 × 2 = 0.5625

0.5625 × 2 = 1.125

0.125 × 2 = 0.25

×

floating point ←—•—→



0.00390625

float → 32bit → single precision

double 64bit

sign → +1 → منفی
0 → مثبت

0 S	1	0	0	0	0	0	1	0	0	0	1	0	0	1	0	0	1	----	0

1 bit — Exponent 8 bit — Mantissa 23 bit (2^{-1}, 2^{-2}, 2^{-3} ... ; 2^{-3}, 2^{-6}, 2^{-9})

float → 275 clock — 1 clock / 14 clock — fpu ↔ cpu

9.140625 — DSP — AVR

9 / 2 = 4 r 1; 4 / 2 = 2 r 0; 2 / 2 = 1 r 0

1001.001001 0000 ---- 0

0.140625 × 2 = 0.28125
0.28125 × 2 = 0.5625
0.5625 × 2 = 1.125
0.125 × 2 = 0.25
0.25 × 2 = 0.5
0.5 × 2 = 1
0 × 2 = 0

$1001.001001 \times 2^{0+1}$

$100.1001001 \times 2^{1+1}$

$10.01001001 \times 2^{2+1}$

1.001001001×2^{3} (حل)

Mantissa

Exponent = 3 + 127 = 130

bias

$(2)^{-37}$, → 126

$S\,(1+\text{mantissa})\,2^{\text{Exponent}}$

S: +/−

Exponent = 130 − 127 = 3

$\pm 2^{-126} = \pm 1.755 \times 10^{-38}$

$\pm 2^{128} = \pm 3.403 \times 10^{38}$

float

Mantissa = $2^{-3} + 2^{-6} + 2^{-9} = 0.142578125$

$+(1 + 0.142578125)\, 2^{3} = 9.140625$ ✓

Exponent	Mantissa	Exponent	Mantissa
∞ ← 11111111	All Zero	00000000	All Zero → 0 (Zero)
% ← 11111111 (NaN)	Not all Zero	00000000 small number ←	Not all Zero