Information Representation

Number systems and values
Floating point arithmetic

Unsigned Binary

$$Value = \sum_{i=0}^{n-1} b_i \times 2^i$$

11110000 = 240

1111000011110000 = 61,680

Unsigned Binary Patterns

0000 0001 = 1

0000 0010 = 2

0000 0100 = 4

0000 1000 = 8

0000 1010 = 10

0001 0000 = 16

0001 1010 = 16 + 10 = 26

Unsigned Binary, Fixed Point

$$Value = \sum_{i=0}^{n-1} b_i \times 2^i \times 2^{-p}$$

1111.0000 = 15

11110000.11110000 = 240.9375

1111.000011110000 = 15.05859375

1.111000011110000 = 1.88232421875

Eighth's:		Sixteenth's:	
1	0.125	1	0.0625
2	0.250	3	0.1875
3	0.375	5	0.3125
4	0.500	7	0.4375
5	0.625	9	0.5625
6	0.750	11	0.6875
7	0.875	13	0.8125
		15	0.9375

0.1111 1111 1111 1111	base 2
0.FFFF	base 16
0.9999847412109375	base 10

Unsigned Binary

- $Value = \sum_{i=0}^{n-1} b_i \times 2^i$
- Positional number system
- $Maximum = 2^n - 1$
- $Minimum = 0$
- Δr = 1

Two's Complement

$$Value = -b_{n-1} \times 2^{n-1} + \sum_{i=0}^{n-2} b_i \times 2^i$$

11110000 = -16

1111000011110000 = -3,856

Two’s Complement Patterns

0000 0001 = 1

0000 0010 = 2

0000 0100 = 4

0000 1000 = 8

0000 1010 = 10

0001 0000 = 16

0001 1010 = 16 + 10 = 26

Two’s Complement Patterns

1000 0001 = 1 + -128 = -127

1000 0010 = 2 + -128 = -126

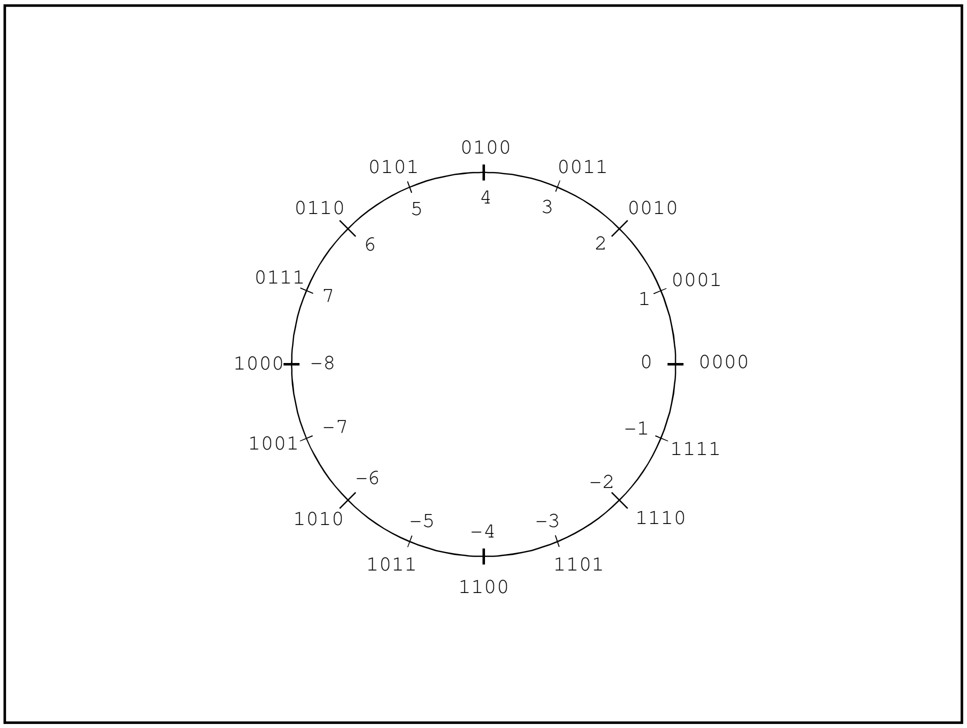
1000 0100 = 4 + -128 = -124

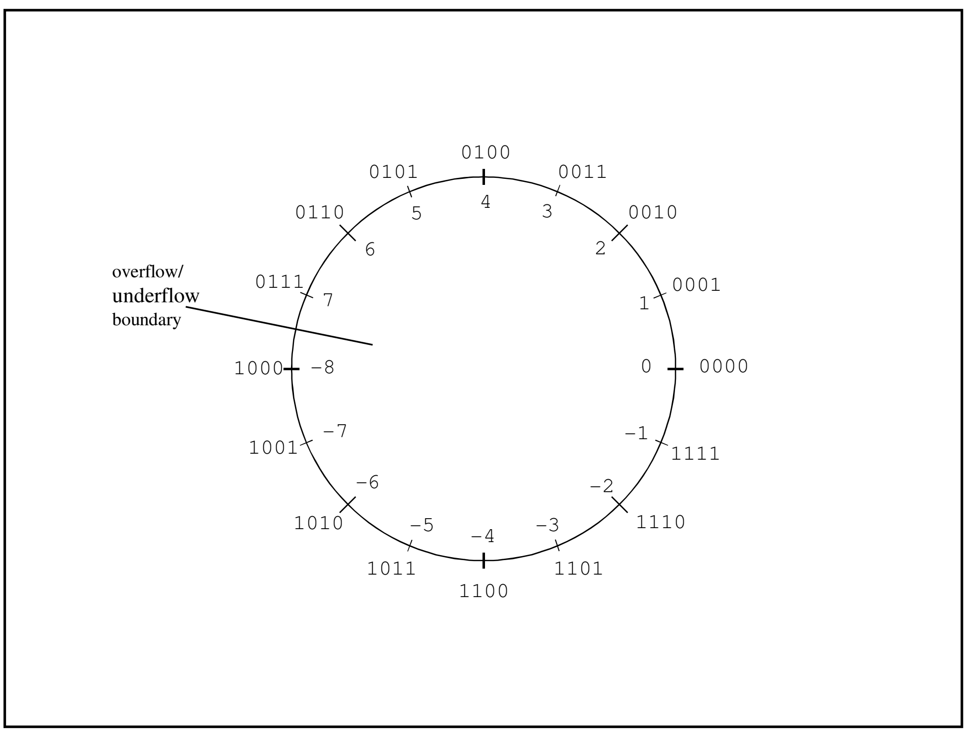
1000 1000 = 8 + -128 = -120

1000 1010 = 10 + -128 = -118

1001 0000 = 16 + -128 = -112

1001 1010 = 16 + 10 + -128 = -102


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


overflow/
underflow
boundary
0100
0011
0010
0001
0000
1111
1110
1101
1100
1011
1010
1001
1000
0111
0110
0101
4
3
2
1
0
-1
-2
-3
-4
-5
-6
-7
-8
7
6
5

Two's Complement

- $Value \quad = \quad -b_{n-1} \times 2^{n-1} + \sum_{i=0}^{n-2} b_i \times 2^i$
- Positional number system
- $Maximum = 2^{n-1} - 1$
- $Minimum = -2^{n-1}$
- $\Delta r = 1$
- Circular Nature

Two's Complement, Fixed Point

$$Value = (-b_{n-1} \times 2^{n-1} + \sum_{i=0}^{n-2} b_i \times 2^i) \times 2^{-p}$$

1111.0000 = -1

11110000.11110000 = -15.0625

1111.000011110000 = -0.94140625

1.111000011110000 = -0.11767578125

Fixed Point

- Can be used with Unsigned Binary or Two's Complement
- Include radix point *p* digits to left of integer position
- Value = $(Value_{UB}) \times r^{-p}$ or $(Value_{2C}) \times r^{-p}$
- Positional number system
- Δr = r^{-p}