Number representation

Signed Magnitude

$6 \rightarrow 0\ 110$

$-6 \rightarrow 1\ 110$

$\uparrow$ sign

Two representations for zero!

$1000_2 \rightarrow -0_{10}$

$0000_2 \rightarrow 0_2$

another problem: adding positive and negative numbers

One's complement:
flip all bits for negative

$7 \rightarrow 0\ 111$

$-7 \rightarrow 1\ 000$

Still has 2 representations for zero

$1111_2 \rightarrow -0_{10}$

$0000_2 \rightarrow 0_{10}$

Adding positive and negative still has a problem:

$$0\ 1\ 0\ 1 \qquad 5$$
$$+\ 1\ 0\ 1\ 0 \qquad +(-5)$$
$$\overline{\qquad\qquad}$$
$$1\ 1\ 1\ 1 \rightarrow -0$$

$+1 \downarrow$

$1\ 0\ 0\ 0\ 0$
   $\underbrace{\qquad}_{0}$

Correct, but by adding 1 we get a better representation of 0

$$0\ 1\ 0\ 1 \qquad 5$$
$$+\ 1\ 1\ 0\ 0 \qquad +(-3)$$
$$\overline{\qquad\qquad}$$
$$1\ \underbrace{0\ 0\ 0\ 1}_{1} \quad \text{\sout{$\ast$}} \quad 2$$
$$\nearrow\ +1$$

$$0\ 1\ 1\ 0 \qquad 6$$
$$+\ 1\ 1\ 0\ 1 \qquad +(-2)$$
$$\overline{\qquad\qquad}$$
$$1\ \underbrace{0\ 0\ 1\ 1}_{3} \quad \text{\sout{$\ast$}} \quad 4$$
$$\nearrow\ +1$$

Pattern: leading 1 and off by 1

Two's complement

$$-8 \quad 4 \quad 2 \quad 1$$

$$6 \rightarrow 0 \ 1 \ 1 \ 0$$

$$-6 \rightarrow 1 \ 0 \ 1 \ 0 = -8 + 2 = -6$$

The most significant bit is negative while the rest are positive

more examples:

$$-7 = -8 + 1 \rightarrow 1000 + 0001 = 1001$$

$$-4 = -8 + 4 \rightarrow 1100$$

negative to positive conversion:
1. flip all bits
2. add 1

ex: $-5 = -8 + 3 = 1011$

① $1011 \rightarrow 0100$

② $0100 + 0001 = 0101 \rightarrow 5_{10}$

positive to negative conversion:
1. subtract 1
2. flip all bits

ex: $7 = 0111$

① $0111 - 0001 = 0110$

② $0110 \rightarrow 1001 \rightarrow (-8) + 1 = -7_{10}$

Addition is now correct

$$0 1 1 0 \qquad 6$$

$$+ 1 1 1 0 \qquad + (-2)$$

$$\overline{1 0 1 0 0} \rightarrow 4$$

$$\underbrace{}_{4} \quad \text{Correct}$$

Packed decimal (Binary Coded Decimal):
each digit is replaced with 4 bit equivalent

ex; 5 3 7 2 $\xrightarrow{BCD}$ 0101 0011 0111 0010

Parity:
Check the number of 1s
-even parity: total numbers of 1 is even
-odd parity: odd

ex: 0110 0001 has odd parity
ex: 0001 1000 has even parity