

Binary Addition and Subtraction



- The rules for addition:

$$0+0=0$$

$$0+1=1$$

$$1+0=1$$

$$1+1=0 \text{ (carry)}$$

- The rules for subtraction:

$$0-0=0$$

$$0-1=1 \text{ (1-borrow)}$$

$$1-0=1$$

$$1-1=0$$

Sign-magnitude system (DC)

- If the signs of the addends are the same we add the magnitudes and give the result of the same sign, if the signs are different we compare the magnitudes, subtract the lower from the higher one and give as resultant sign the sign of the higher value. All the comparisons and decision steps to do in this algorithm shift into large and complex circuits. Adders for complement number systems are much simpler.
- The addition in the signed-magnitude system has two main drawbacks:
 - The sign and the digital part are examined separately
 - We need two different hardware devices to make addition and subtraction possible: an adder and a subtractor.
 - That's why the signed-magnitude system is not used for addition but it is used for multiplication.

- $X=7$

- $Y=-16$

- $X+Y$

- $X=-24$

- $Y=30$

- $X+Y$



Addition and Subtraction in One's Complement System

- If we represent the negative number in the one's complement system we can substitute the subtraction with addition:
- $A - B = A + B_{1C}$
- In a one's complement system representation the sign and the digital part are examined together and the result is obtained in one's complement representation.
- We have to consider a particular rule: if there's a carry out of the sign position it is added to the result, this rule is often called "end-around carry".

- $X=63$

- $Y=-7$

- $X+Y$

- $X=-34$

- $Y=21$

- $X-Y$



Addition and Subtraction in Two's Complement System

- If we represent the negative number in the two's complement system we can substitute the subtraction with addition:
- $A - B = A + B_{CC}$
- In a two's complement system representation the sign and the digital part are examined together and the result is obtained in two's complement representation.
- Addition rule: add ignoring any carry out of the MSB.

- $X=63$

- $Y=-7$

- $X+Y$

- $X=-34$

- $Y=21$

- $X-Y$



- $X = -56$
- $Y = -23$
- $X + Y$

- $X = 120$
- $Y = 70$
- $X - Y$



Overflow and Underflow

- If an addition operation produces a result that exceeds the range of the number system, overflow is said to occur. Overflow can occur during addition of two positive numbers or two negative numbers. Addition of two numbers with different signs can never produce an overflow.



- $X = -102$
- $Y = -80$
- $X + Y$

- $X = 100$
- $Y = -90$
- $X - Y$

