

Binary Multiplication

101×011 unsigned = ?

Q2.0 101 5_{10} Always pad with zeros

Q2.0 x011 3_{10}

 101

∑ 1010

 0000

Q4.0 01111 15_{10} ✓

pad with 'order' number of zeros.

Q3 1101 13_{10} unsigned.

Q4 x11011 27_{10}

 1101

∑ 111010

 1000000

 11101000

 11010000

$$Q_{n.m} = Q_{(n_1+n_2)} \cdot (m_1+m_2)$$

Q7 [] 01011111

010.0110 x 01.10 1.5_{10} unsigned.

Q2.4 010.0110 2.375_{10}

Q1.2 x 01.10

 00000000

∑ 01001100

 01001100

 06000000

Q3.6 0101.100100 3.5625_{10}

101x011 signed (2^1).
 $-3_{10} \times 3_{10}$

$-83_{10} \Rightarrow -x 83$
 $\Rightarrow -1x01010011$

invert and add an LSB.

$\Rightarrow 10101100 + \text{LSB}$
 $\Rightarrow 10101101$

$83 \div 2 = 41 \text{ r}1$
 $41 \div 2 = 20 \text{ r}1$
 $20 \div 2 = 10 \text{ r}0$
 $10 \div 2 = 5 \text{ r}0$
 $5 \div 2 = 2 \text{ r}1$
 $2 \div 2 = 1 \text{ r}0$
 $1 \div 0 = 0 \text{ r}1$

	101	-3_{10}
	x011	$+3_{10}$
	101	
Σ	1010	
	00000	
	01111	$+15_{10} ? (\text{wtf?})$

FIRST UNSIGN ALL NEGATIVE NUMBERS

$-1x011x011 = 01001x-1$
 $= 10110 + \text{LSB}$
 $= 10111$

	011
	x011
	011
	0110
	00000
	01001

$$\begin{aligned}
 & 1001.11 \times 10.0111 \quad \text{signed.} \\
 & = -1 \times 0110.01 \times -1 \times 01.1001 \\
 & = 0110.01 \times 01.1001 \\
 & = 01001.110001 \quad \text{Q4.6 signed.}
 \end{aligned}$$

$$\text{Q3.2} \quad 0110.01$$

$$\text{Q1.4} \quad \begin{array}{r} 01.1001 \\ \hline 011001 \end{array}$$

$$0000000$$

$$\Sigma \quad \begin{array}{r} 0000000 \\ 011001000 \end{array}$$

$$0110010000$$

$$\hline 0000000000$$

$$\text{Q4.6} \quad 01001.110001$$

Carry + overflow

$$1111 \text{ signed} = -1_{10}$$

$$1111$$

$$\begin{array}{r} + 01 \\ \hline [1]0000 \end{array}$$

carry, no overflow \therefore ignore carry

$$1111 \quad -1$$

$$\begin{array}{r} -1000 \quad - -8 \\ \hline 0111 \quad + 7 \end{array}$$

no carry, no overflow

overflow \Rightarrow when sign bit changes incorrectly.

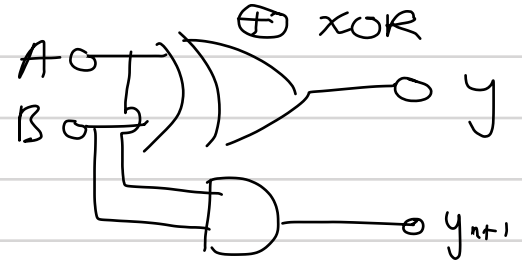
$$0111 \quad + 7$$

$$\begin{array}{r} + 01 \quad + 1 \\ \hline 1000 \quad - 8 \end{array}$$

no carry, but overflow.

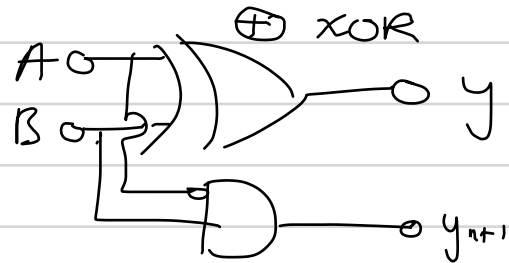
Addition (A+B)

$$\begin{array}{rcl} 0+0 & = & 0 \\ 0+1 & = & 1 \\ 1+0 & = & 1 \\ 1+1 & = & \boxed{0} \end{array}$$



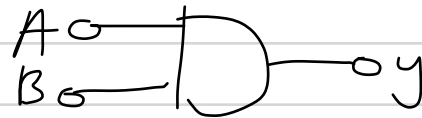
Subtraction

$$\begin{array}{rcl} 0-0 & = & 0 \\ 1-0 & = & 1 \\ 0-1 & = & \boxed{1} \\ 1-1 & = & 0 \end{array}$$

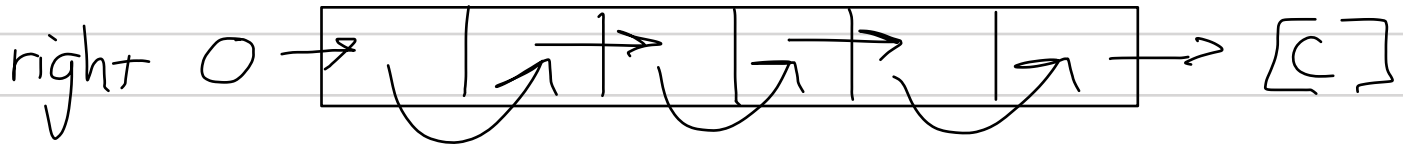
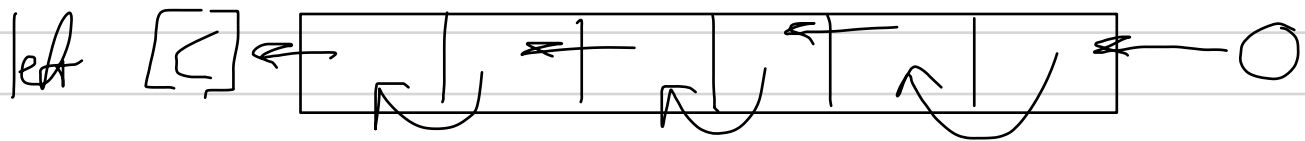


Multiplication

$$\begin{array}{rcl} 0 \times 0 & = & 0 \\ 0 \times 1 & = & 0 \\ 1 \times 0 & = & 0 \\ 1 \times 1 & = & 1 \end{array}$$



Logical shift



Arithmetic shift (big endian)

