Detecting overflow

For $a + b = x$

Sign of x

If a ⊖ve $ b ⊖ve sign bit negative.

If a ⊕ve $ b ⊕ve sign bit positive.

If a ⊖ve $ b ⊕ve sign positive if $|b| > |a|$

If a ⊕ve $ b ⊖ve sign negative if $|b| > |a|$

Fixed point multiplication

$-5 \times +6$

$6 = 0110$ $Q3_s$

$5 = 0101$ $Q3_s$

$-5 = 1011$ $Q3_s$

$$\begin{array}{r} 0110 \\ \times\ 1011 \\ \hline 0110 \\ 01100 \\ 000000 \\ \hline 01\ 10000 \\ \hline 1000010 \end{array} = -62_{10}$$

Q6

$$\begin{array}{r} 1011\ (-5) \\ \times\ 1010\ (-6) \\ \hline 0000 \\ 10110 \\ 000000 \\ \hline 101\ 1000 \\ \hline 1101110 \end{array} \rightarrow 1101110 = -18_{10}!$$

Multiply unsigned numbers together... always.

Fixed point example

$$
\begin{array}{rl}
 & 01.101 \quad Q1.3 \\
\times & 00.110 \quad Q1.3 \\
\hline
 & 00000 \\
 & 01101 \\
 & 01101 \\
 & 00000 \\
\Sigma & 00000000 \\
\hline
 & 001.001110 \quad Q2.6
\end{array}
$$

$$
\underbrace{Qn_1 \cdot m_1}_{\text{multiplicand}} \times \underbrace{Qn_2 \cdot m_2}_{\text{multiplier}} = \underbrace{Q(n_1+n_2) \cdot (m_1+m_2)}_{\text{product}}
$$

Binary division

$360 \div 4 =$

$$
\begin{array}{r}
090 \\
\hline
4 \,\big|\, 360 \\
36 \\
-36 \\
\hline
0
\end{array}
$$

$360_{10} = 101101000$ $\quad Q8.0_u$

$4_{10} = 100$ $\quad Q2.0_u$

```
        001011010
100 ) 101101000
      101
     -100
        110
       -100
         101
        -100
           100
          -100
             0
```

$11 \div 6$

$11_{10} = 01011$ $\qquad 6_{10} = 00110$

```
        00001     rem 101
110 ) 01011
      0X011
    -   110
        101
```

$$
\begin{array}{r|l}
00001 & 1101 \\
\hline
1101\overline{)01011} & 0000000 \\
01011 & \\
-\ 1\ 1\ 0 & \\
\hline
\ \ 1\ 0\ 1\ 0 & \\
-\ \ 1\ 1\ 0 & \\
\hline
\ \ \ 1\ 0\ 0\ 0 & \\
-\ \ \ 1\ 1\ 0 & \\
\hline
\ \ \ \ 0\ 1\ 0\ 0\ 0 & \\
-\ \ \ \ 1\ 1\ 0 & \\
\hline
\end{array}
$$

$1.8333\ldots$