

Sign Extension

- Needed for 2's complement addition
- Consider case of adding two numbers of different widths

$$\begin{array}{r} 1 0 1 1 \quad -5 \\ 0 1 0 0 1 0 \quad +18 \\ \hline 0 1 1 1 0 1 \quad +29! \end{array}$$

Sign Extension

- Rule #1: 2's complement numbers must be the same word-width because of implied zeros

$$\begin{array}{r} 0 0 1 0 1 1 \quad -5 \\ 0 1 0 0 1 0 \quad +18 \\ \hline 0 1 1 1 0 1 \quad +29! \end{array}$$

Sign Extension

- Rule #2: Despite a fundamental change to the number's definition, the value of a 2's complement number will never change due to any amount of sign extension—positive or negative

$$\begin{array}{rcl}
 1\ 0\ 1\ 1 & -5 = & -8 + 2 + 1 \\
 \mathbf{1}\ 1\ 0\ 1\ 1 & -5 = & -16 + 8 + 2 + 1 \\
 \mathbf{1}\ 1\ 1\ 0\ 1\ 1 & -5 = & -32 + 16 + 8 + 2 + 1
 \end{array}$$

Sign Extension

- Procedure:
 - Calculate the width of the answer word so that it contains all input possibilities
 - It's up to you to make sure the output range is sufficient
 - Extend the inputs' sign bits to the width of the answer
 - Add as usual
 - Ignore bits that ripple to the left of the answer's MSB

$$\begin{array}{r|l}
 1\ 1\ 1\ 0\ 1\ 1 & -5 \\
 0\ 1\ 0\ 0\ 1\ 0 & +18 \\
 \hline
 x\ 0\ 0\ 1\ 1\ 0\ 1 & +13 \quad \text{☺}
 \end{array}$$

Sign Extension

- Ignore carry bits
 - Do not spend any hardware calculating any bits to the left of the answer's MSB

	1	1	1	0	1	1	-5
	1	1	0	0	1	0	-14

x	1	0	1	1	0	1	-19 ☺

ignore
all bits to
the left of
the MSB