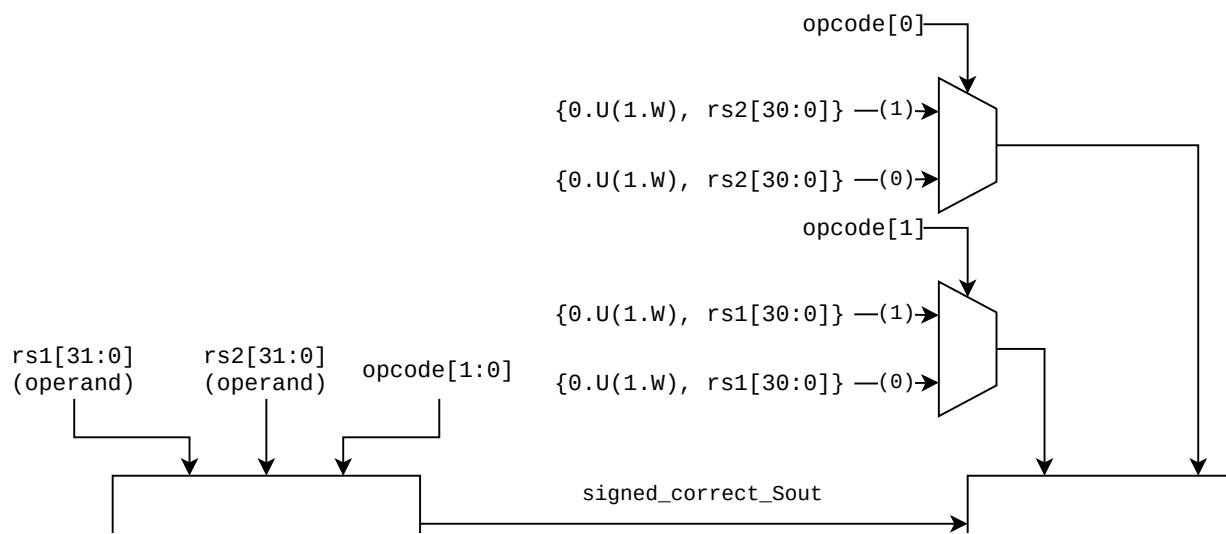
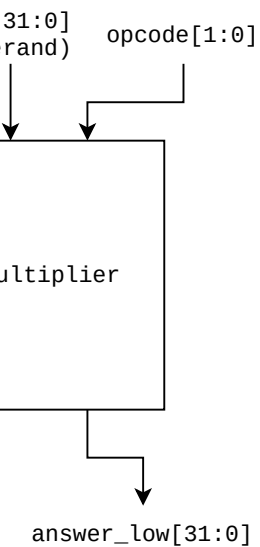
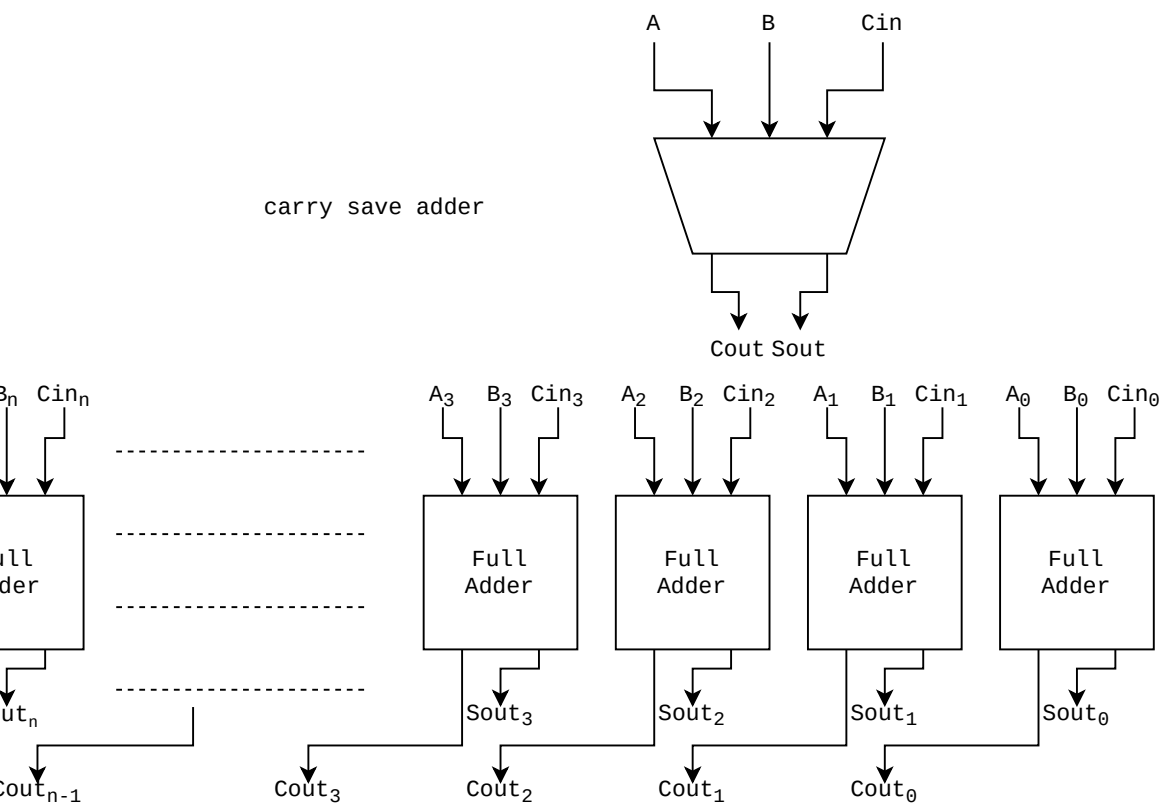


internal blocks of riscv multiplier





opcode[1:0]	operation
"b00".U	unsigned(rs1)xunsigned(rs2)
"b10".U	signed(rs1)xunsigned(rs2)
"b11".U	signed(rs1)xsigned(rs2)

$$rs1 = a_{31}a_{30} \dots a_2a_1a_0$$

$$rs2 = b_{31}b_{30} \dots b_2b_1b_0$$

$$unsigned(rs1) = \sum_{i=0}^{31} a_i * 2^i$$

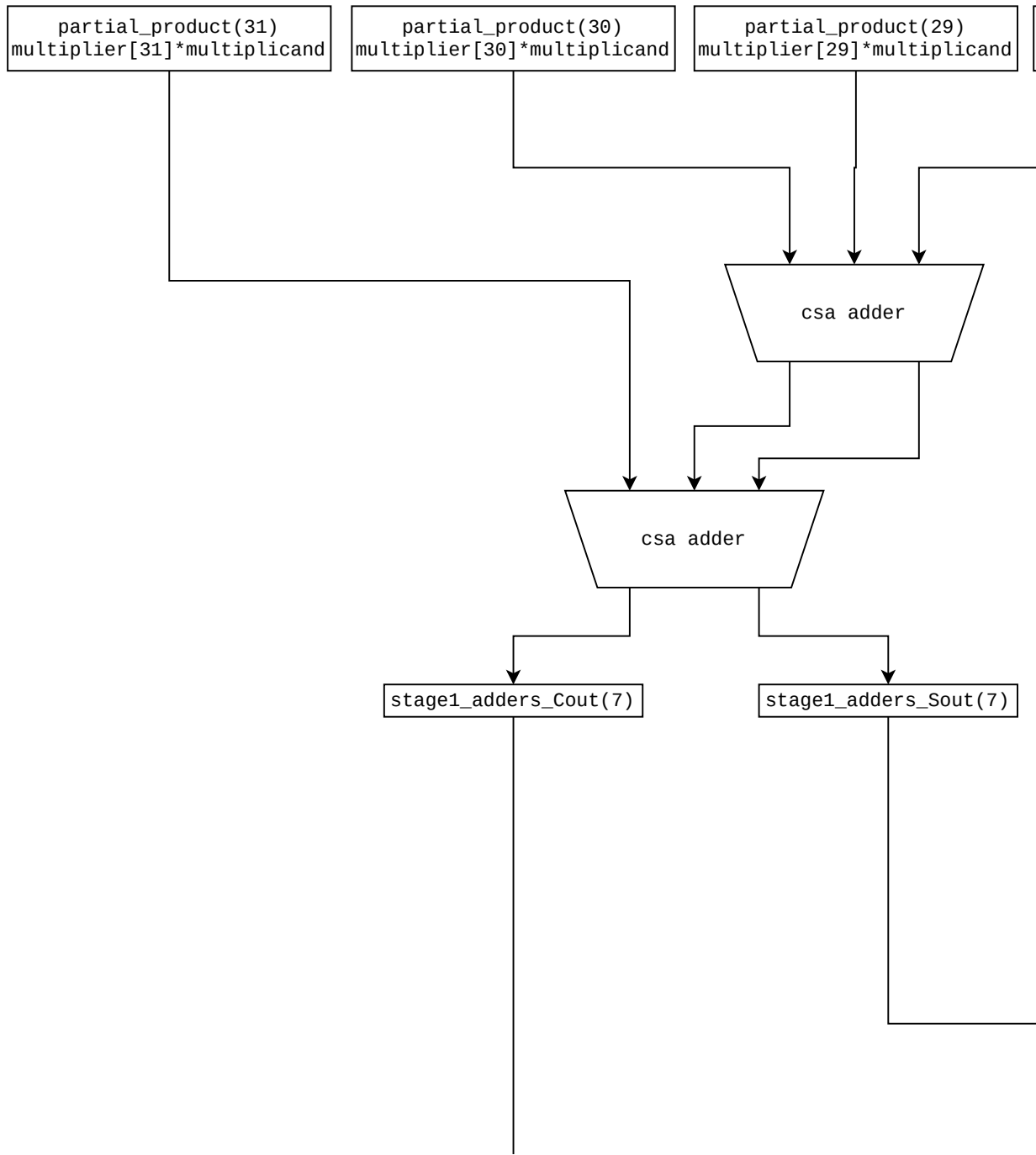
$$signed(rs1) = \sum_{i=0}^{30} a_i * 2^i - a_{31} * 2^{31}$$

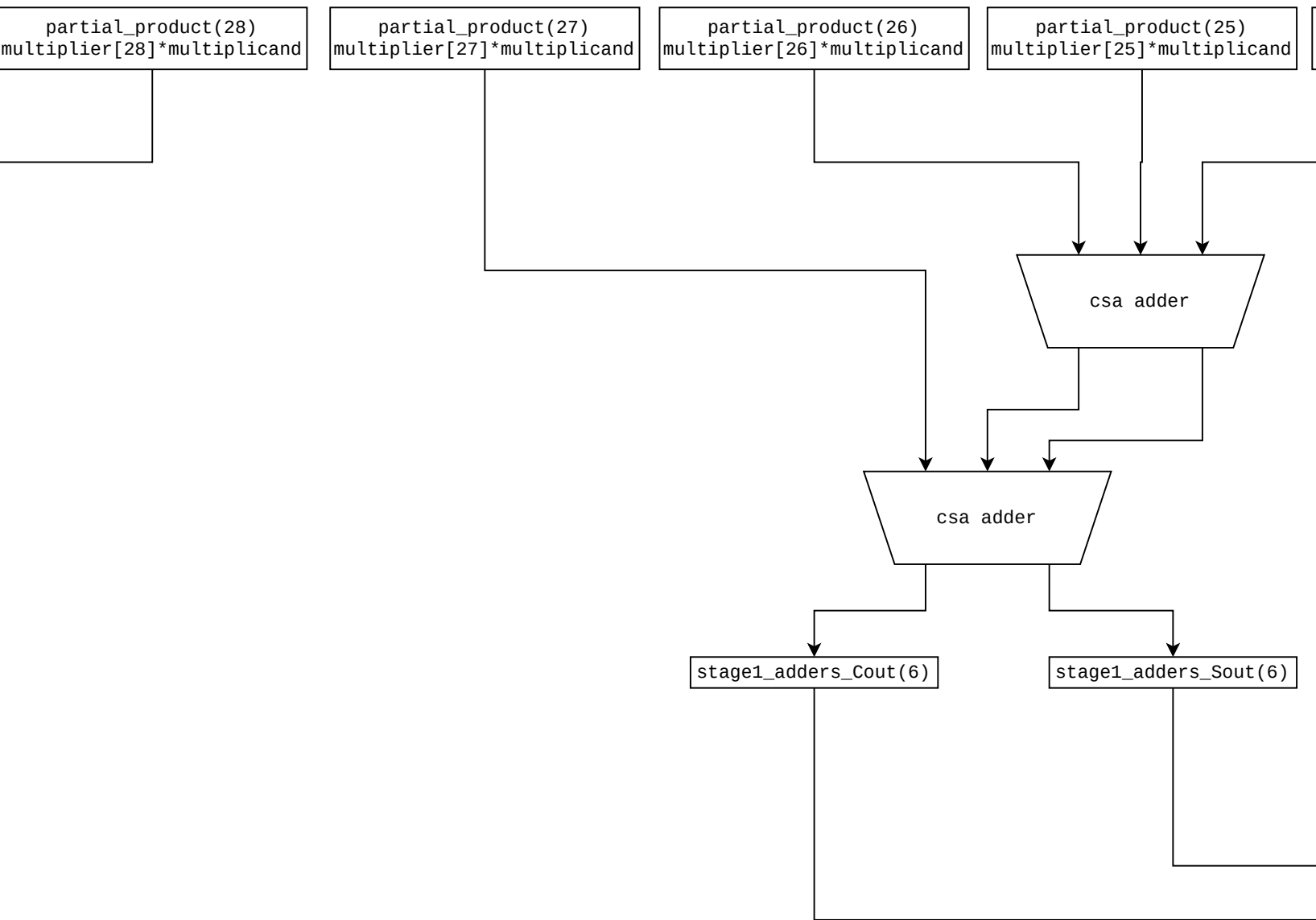
$$unsigned(rs1) * unsigned(rs2)$$

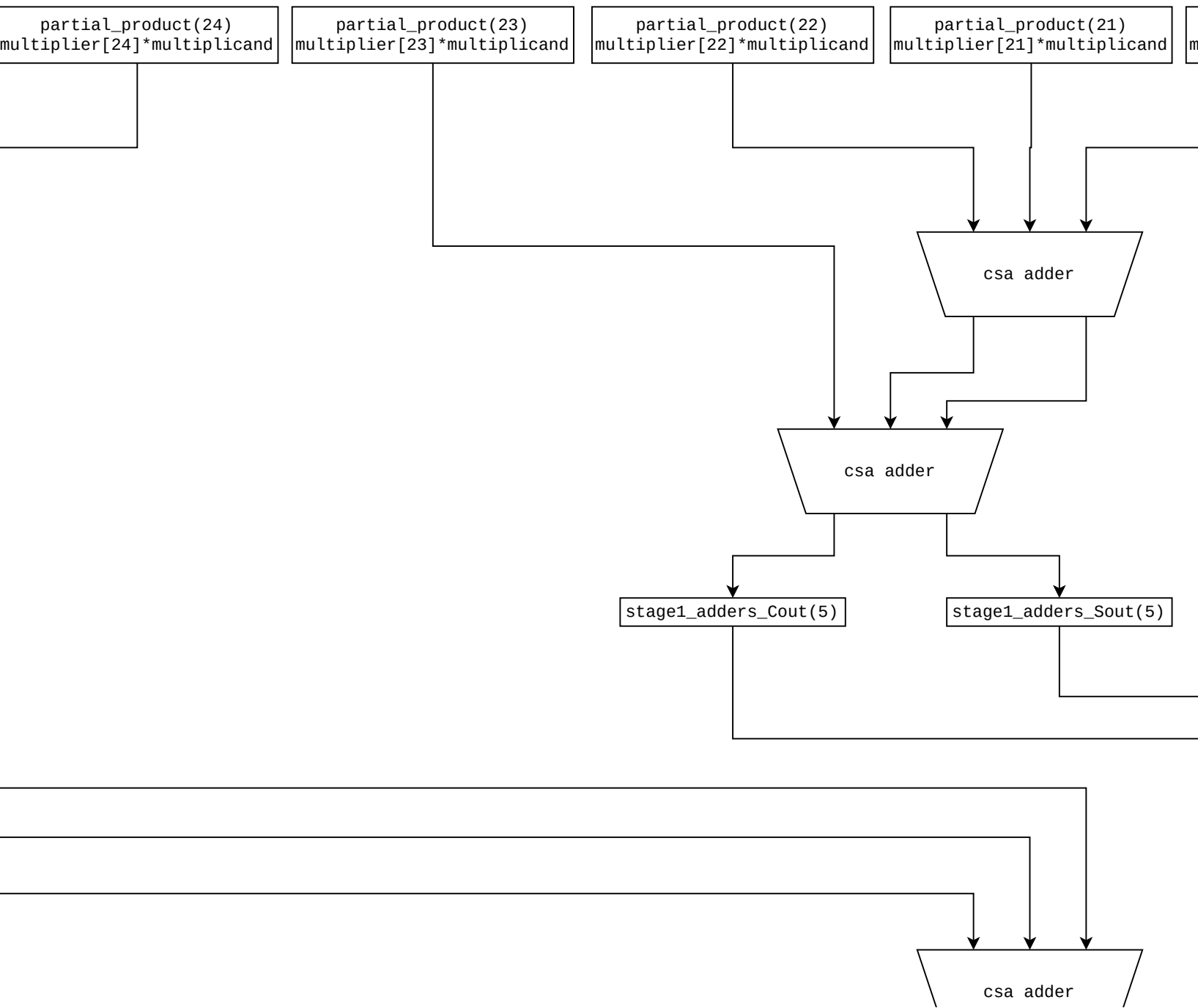
$$= \left(\sum_{i=0}^{31} a_i * 2^i \right) * \left(\sum_{i=0}^{31} b_i * 2^i \right)$$

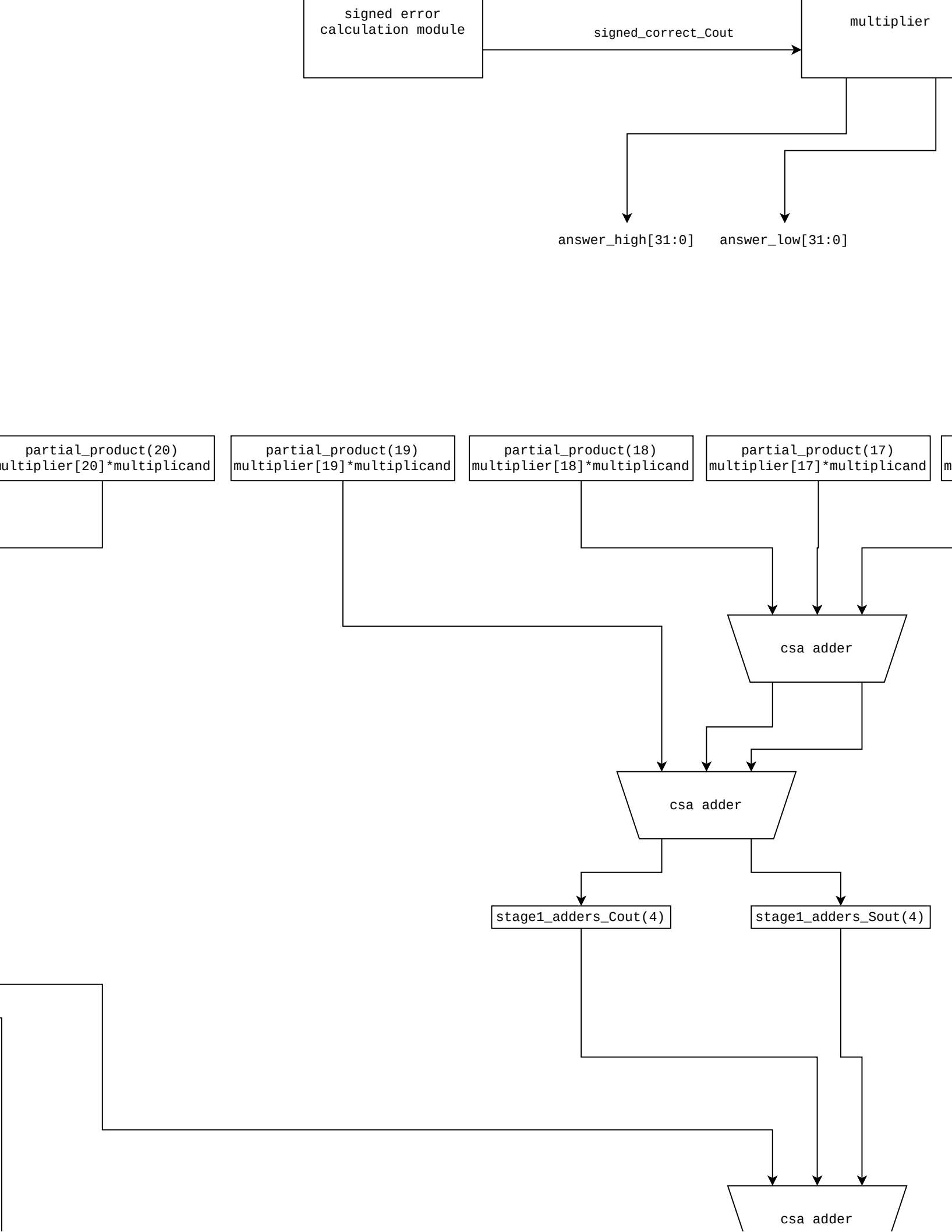
$$signed(rs1) * unsigned(rs2)$$

- for signed operands MSB is set to zero

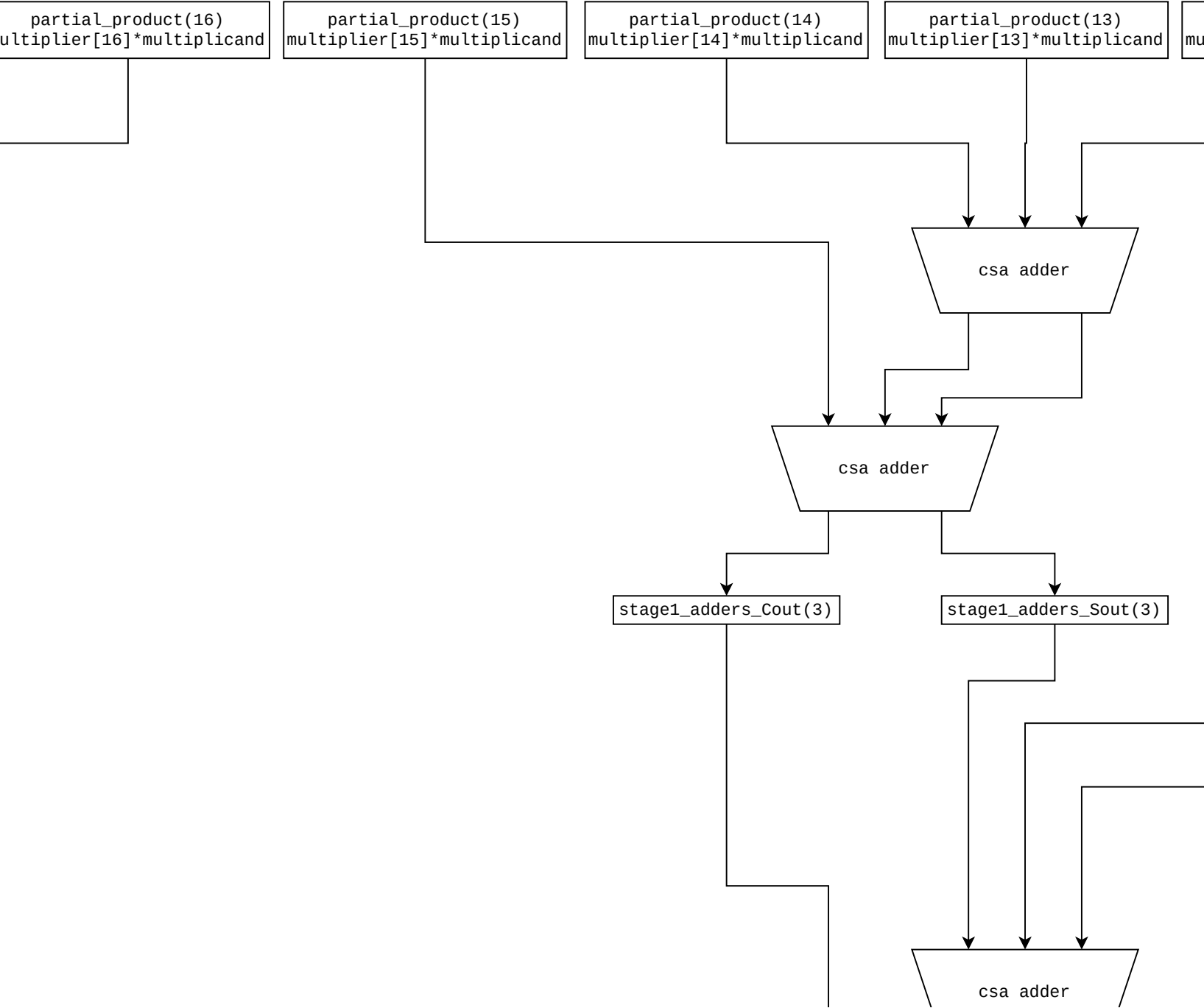




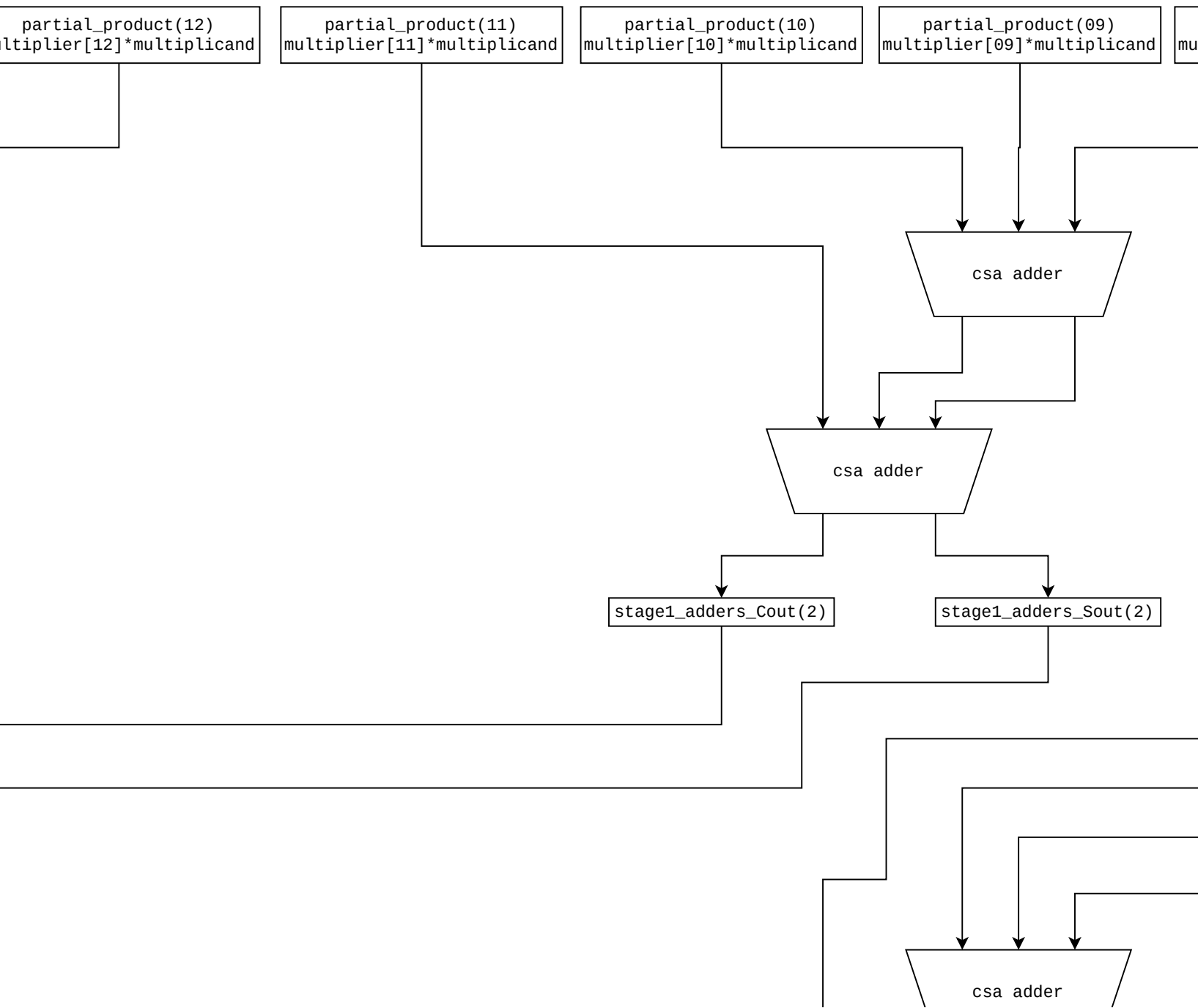


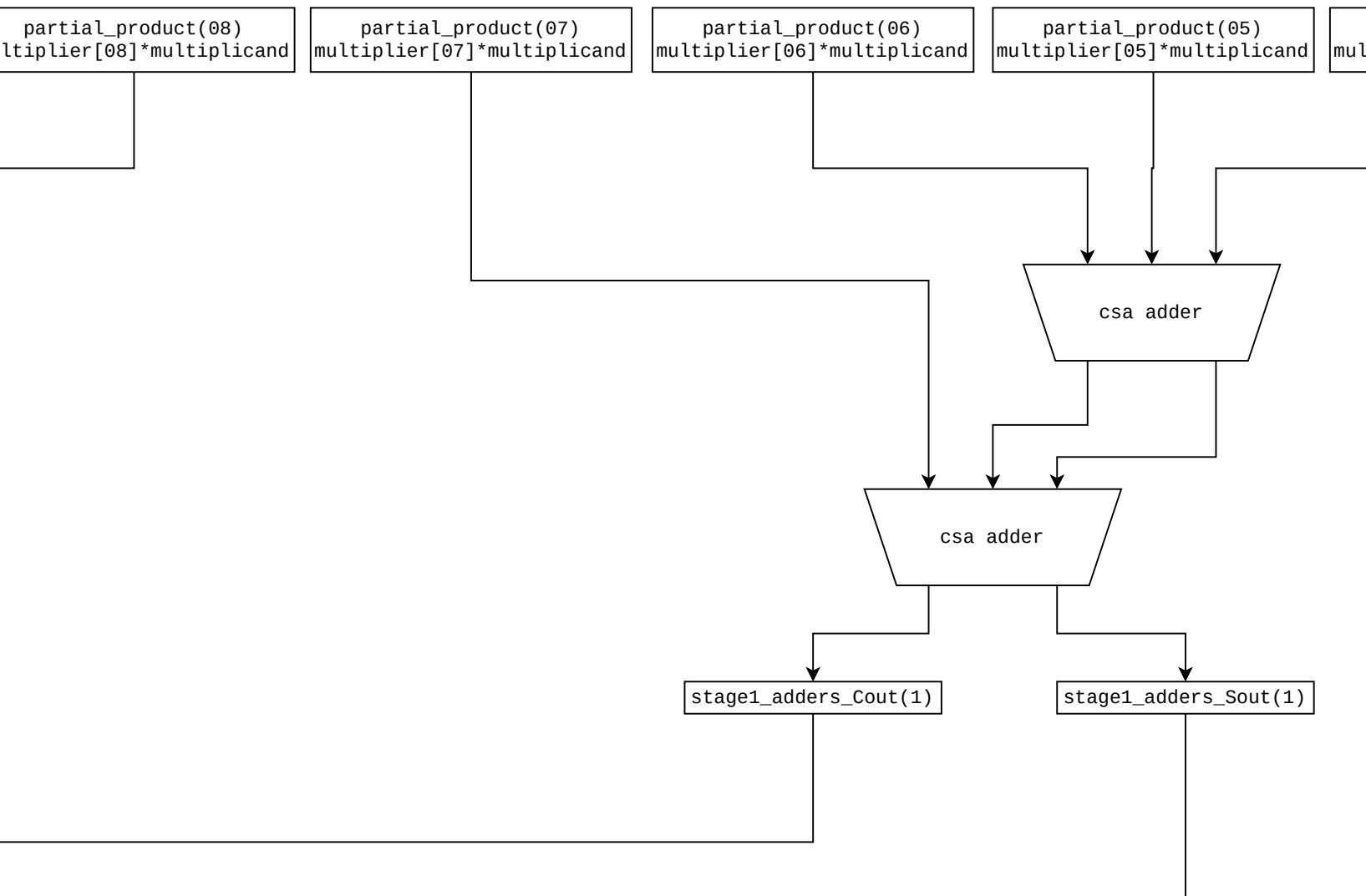


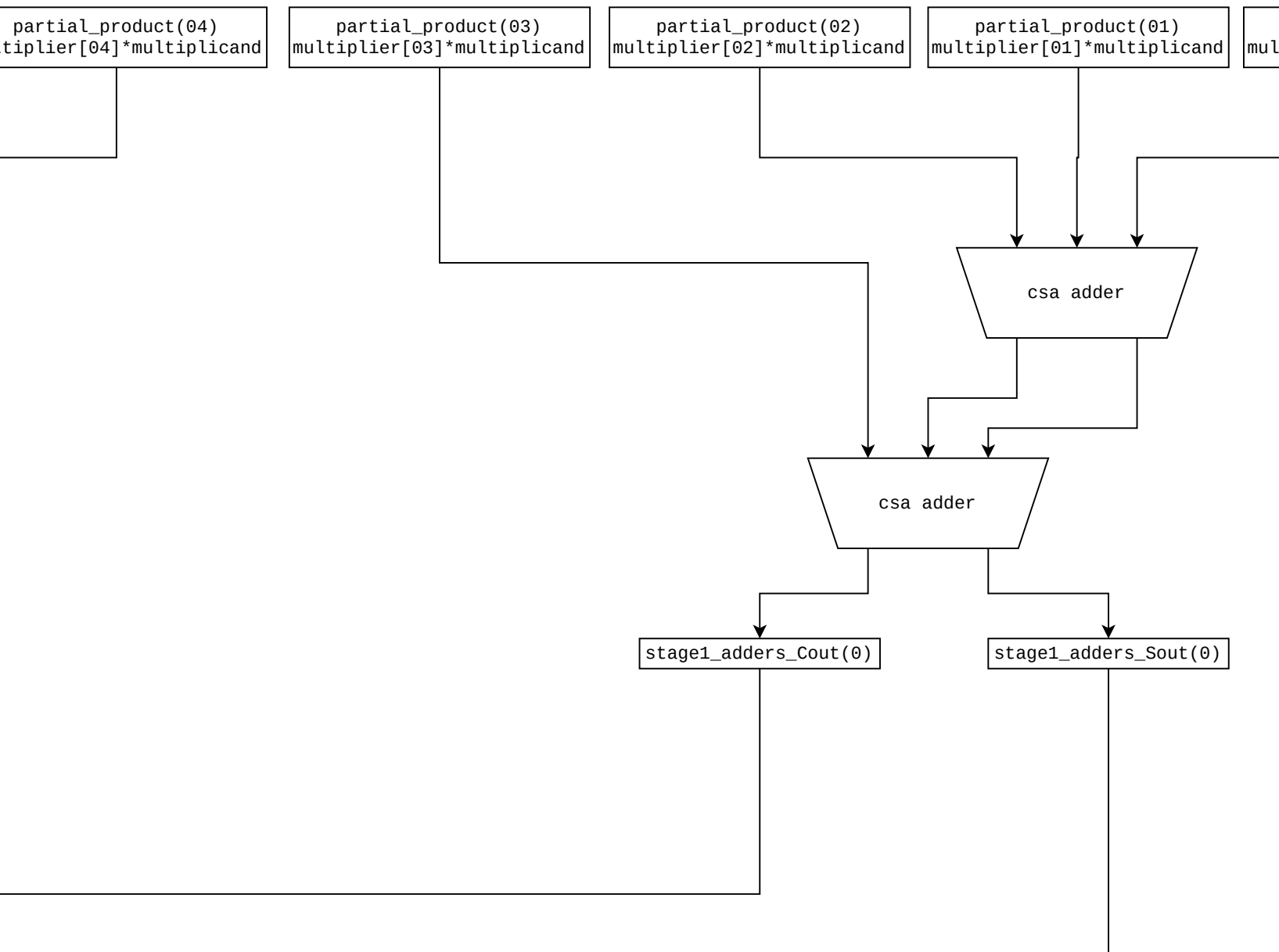
$$\begin{aligned}
 &= \left(\sum_{i=0}^{30} a_i * 2^i - a_{31} * 2^{31} \right) * \left(\sum_{i=0}^{31} b_i * 2^i \right) \\
 &= \left(\sum_{i=0}^{30} a_i * 2^i \right) * \left(\sum_{i=0}^{31} b_i * 2^i \right) - a_{31} * 2^{31} * \left(\sum_{i=0}^{31} b_i * 2^i \right) \\
 &\qquad\qquad\qquad signed(rs1) * signed(rs2) \\
 &= \left(\sum_{i=0}^{30} a_i * 2^i - a_{31} * 2^{31} \right) * \left(\sum_{i=0}^{30} b_i * 2^i - b_{31} * 2^{31} \right) \\
 &= \left(\sum_{i=0}^{30} a_i * 2^i \right) * \left(\sum_{i=0}^{30} b_i * 2^i \right) - a_{31} * 2^{31} * \left(\sum_{i=0}^{30} b_i * 2^i \right) - b_{31} * 2^{31} * \left(\sum_{i=0}^{30} a_i * 2^i \right) + a_{31} * b_{31} * 2^{62}
 \end{aligned}$$



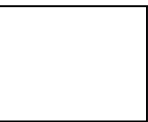
62 *

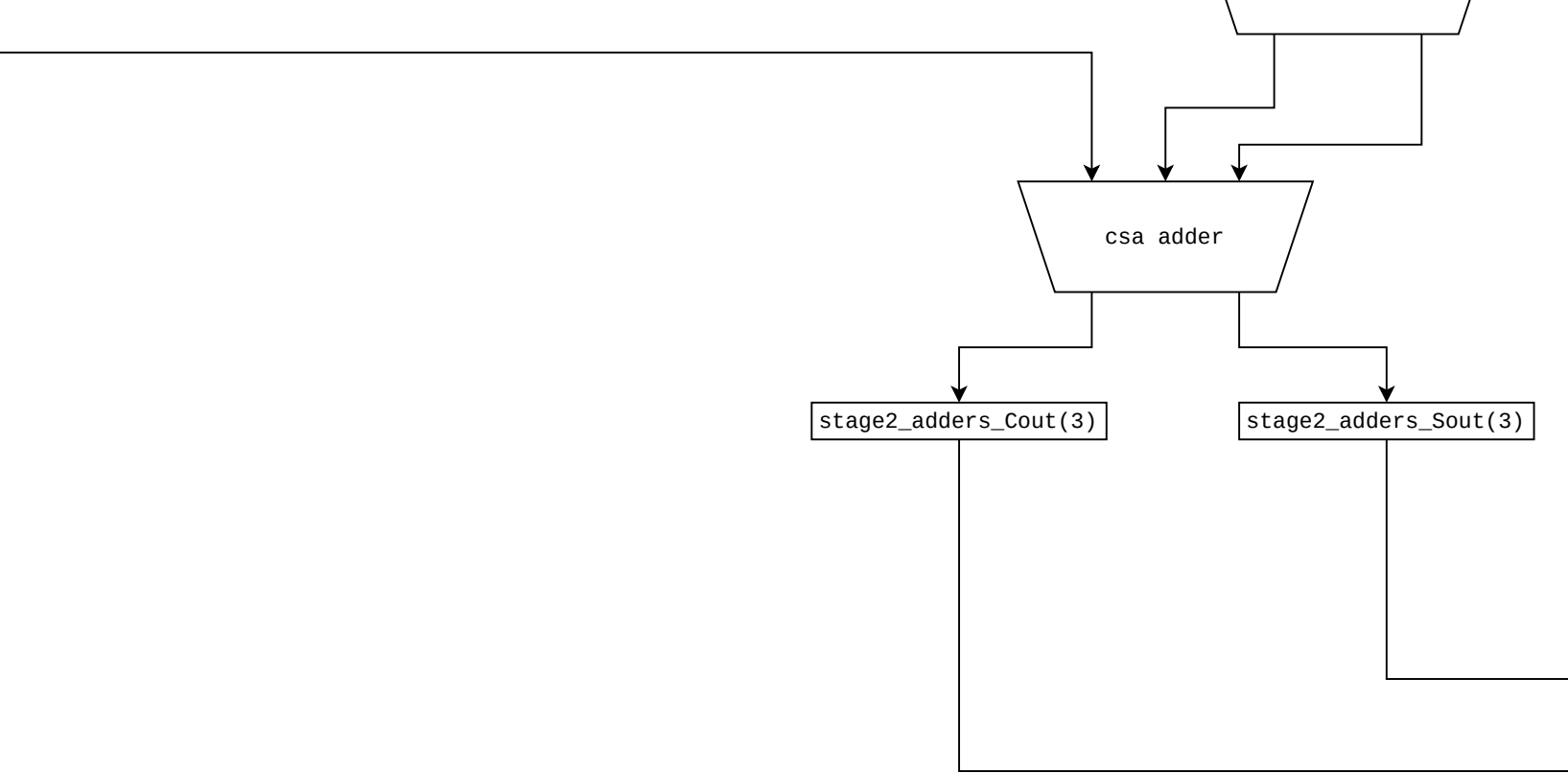


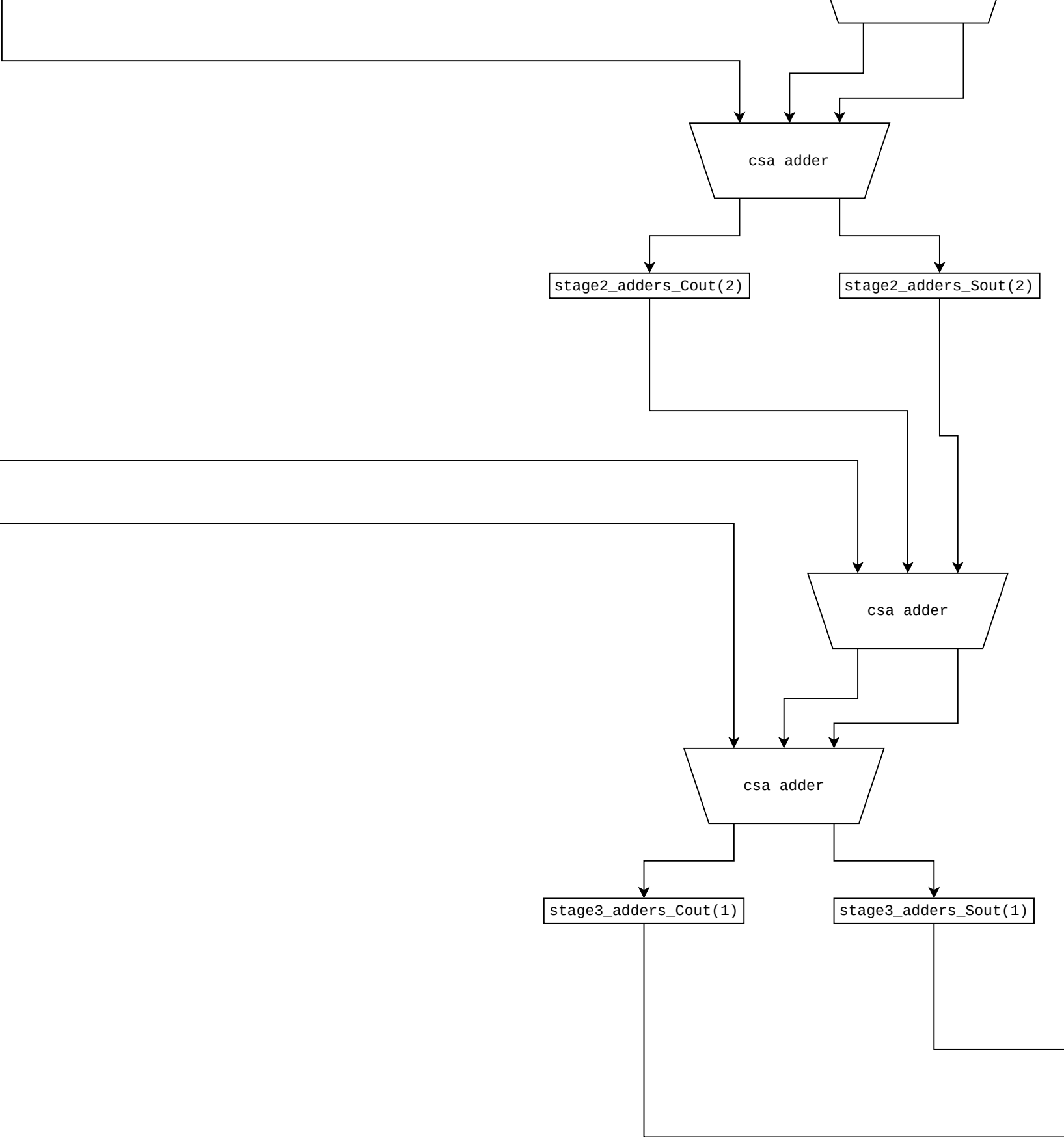


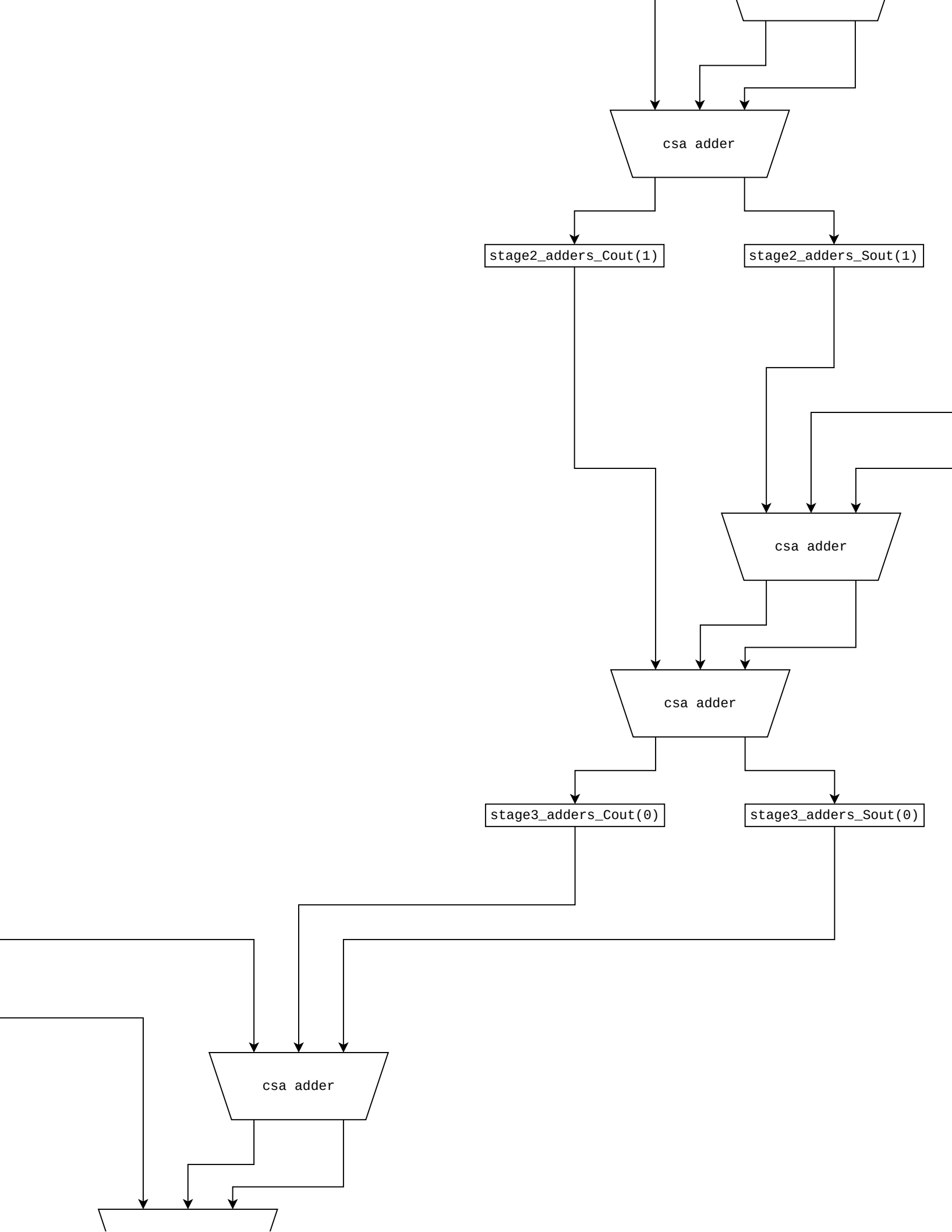


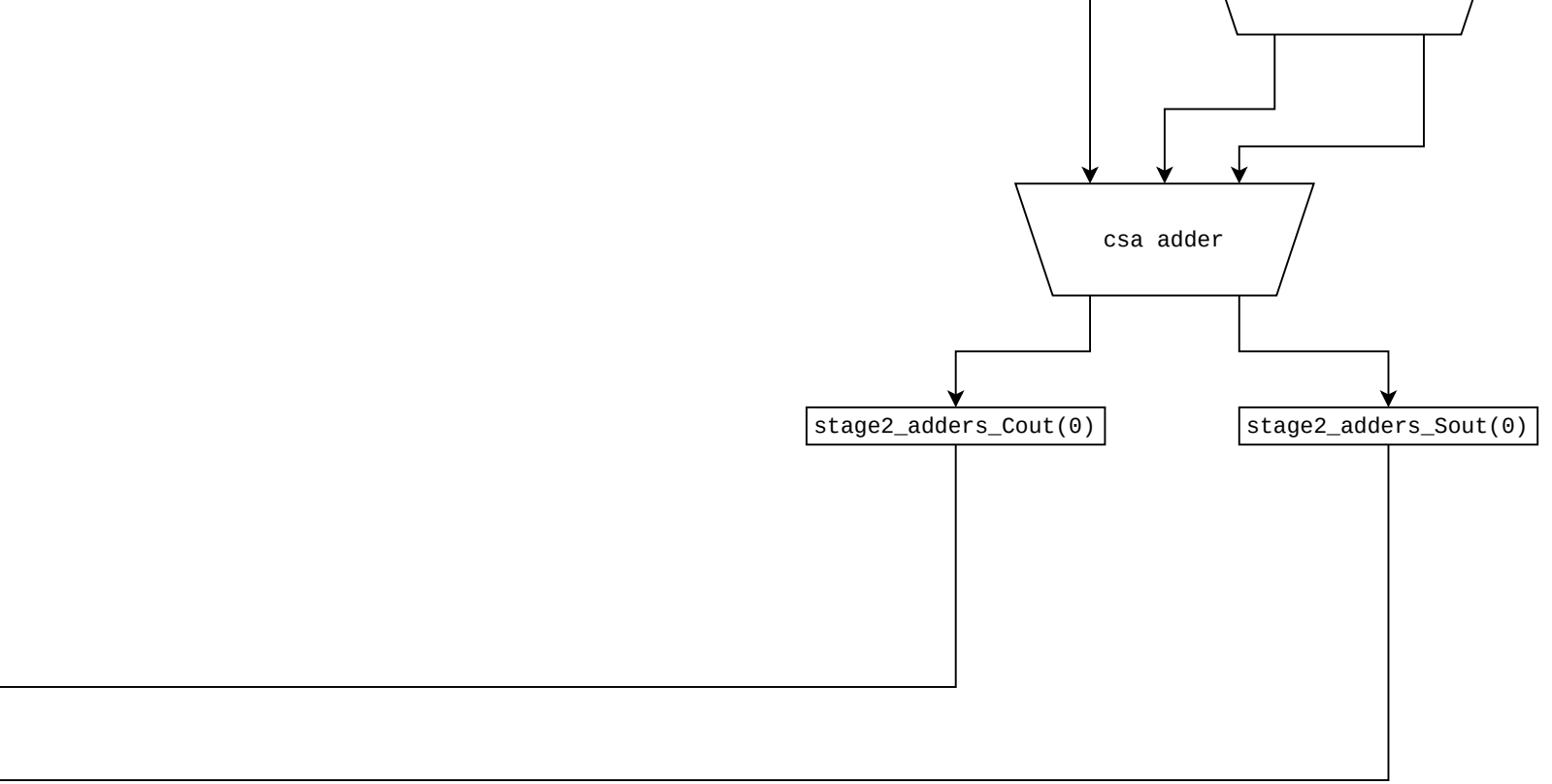

```
partial_product(00)  
multiplier[00]*multiplicand
```



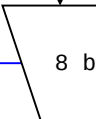
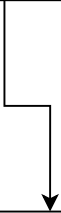


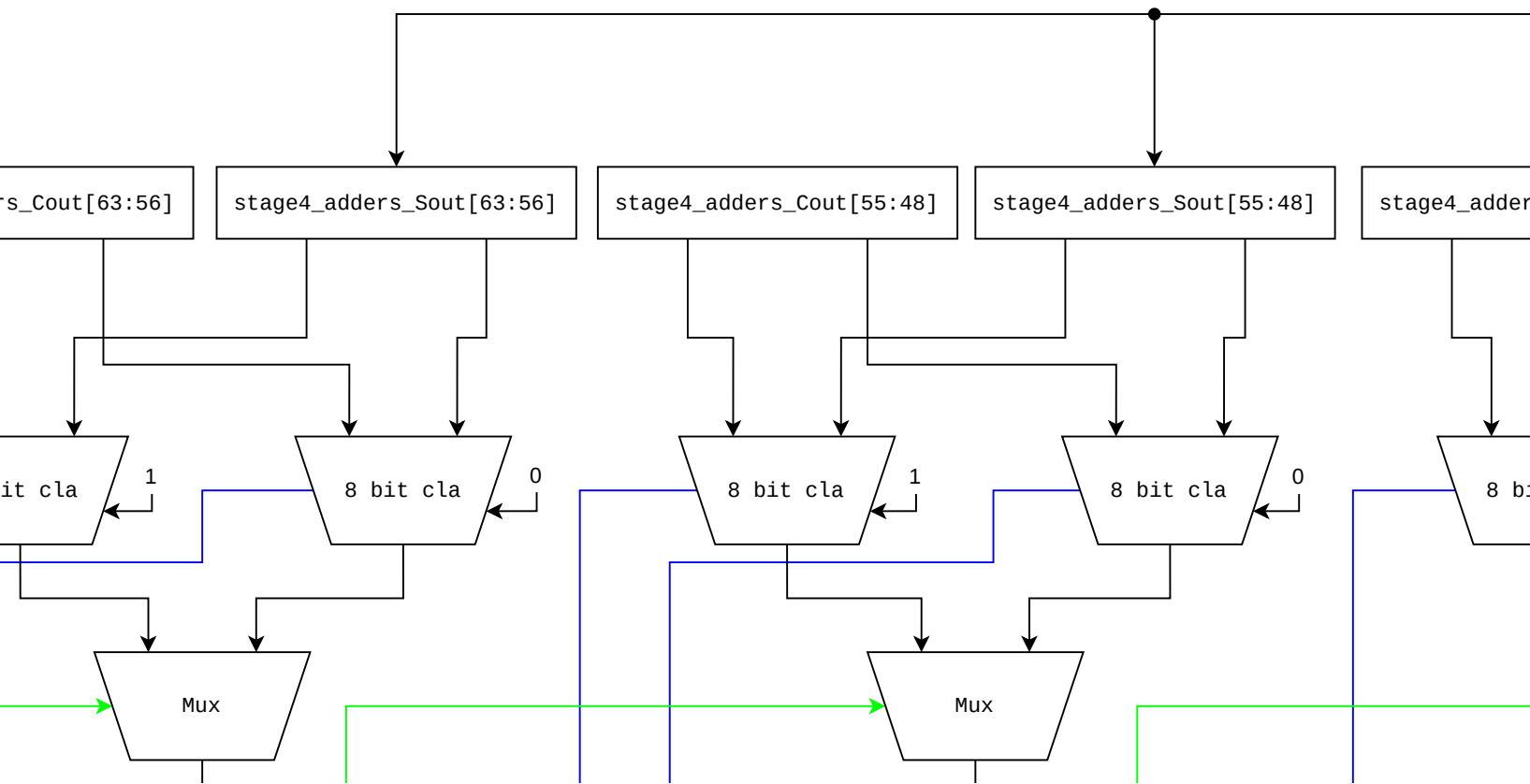


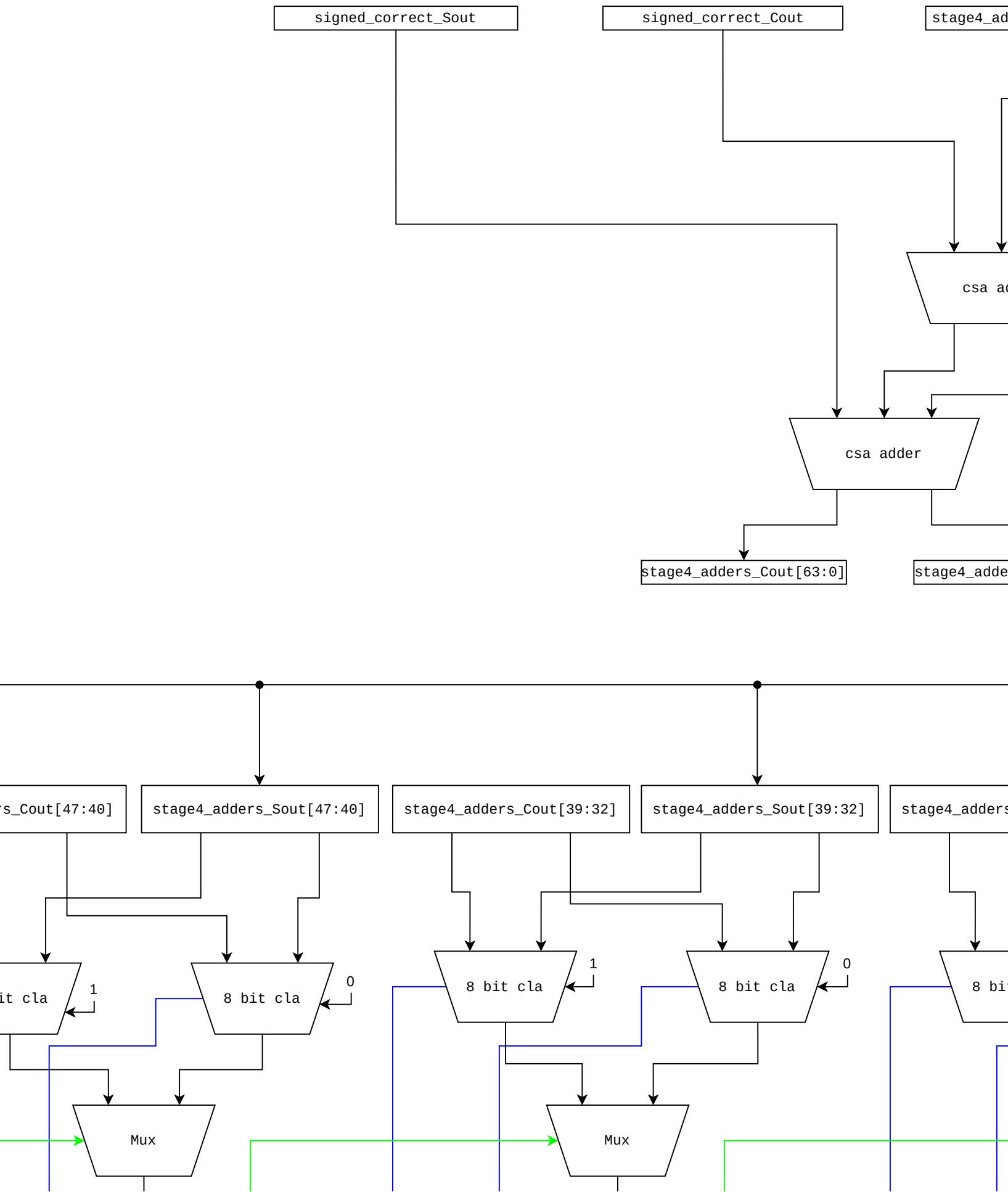


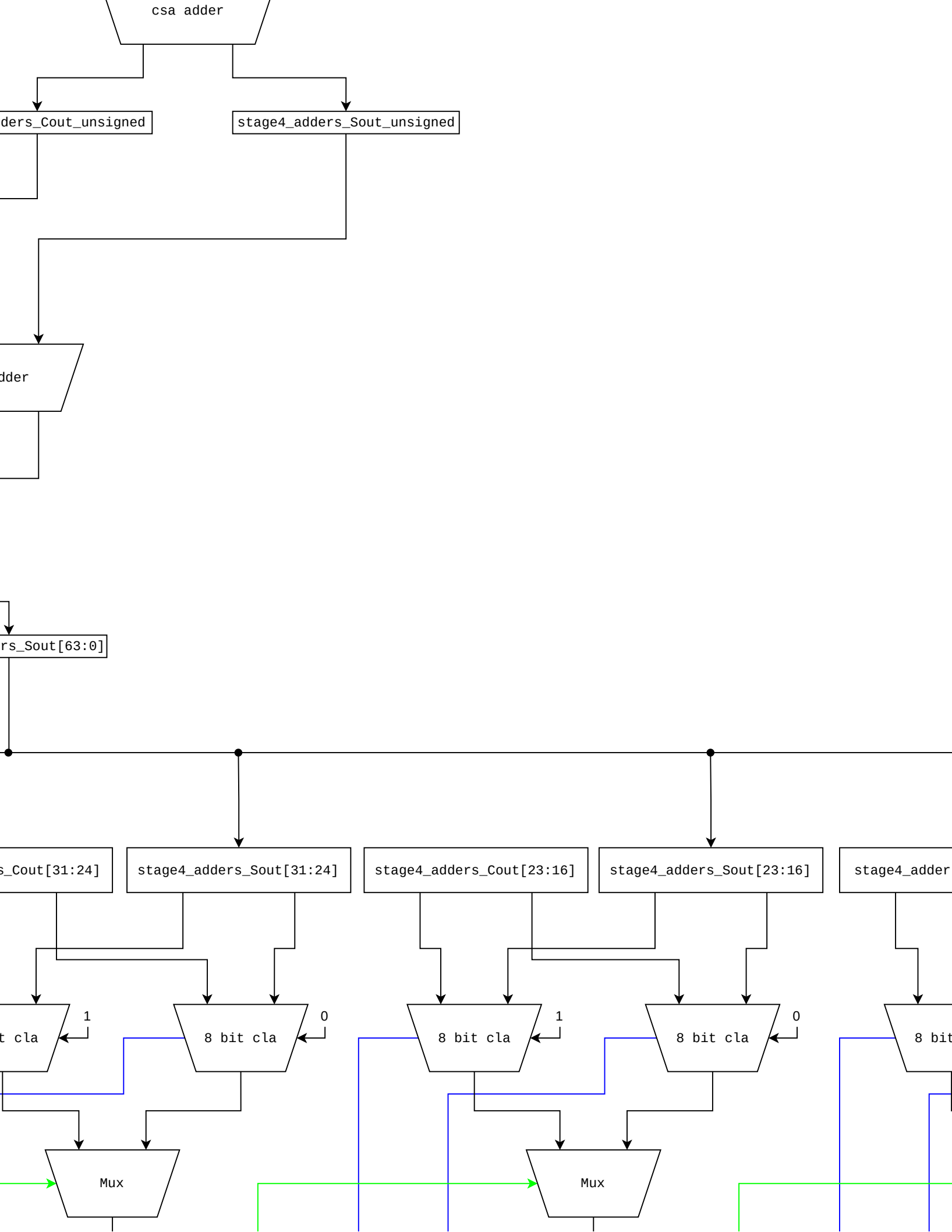


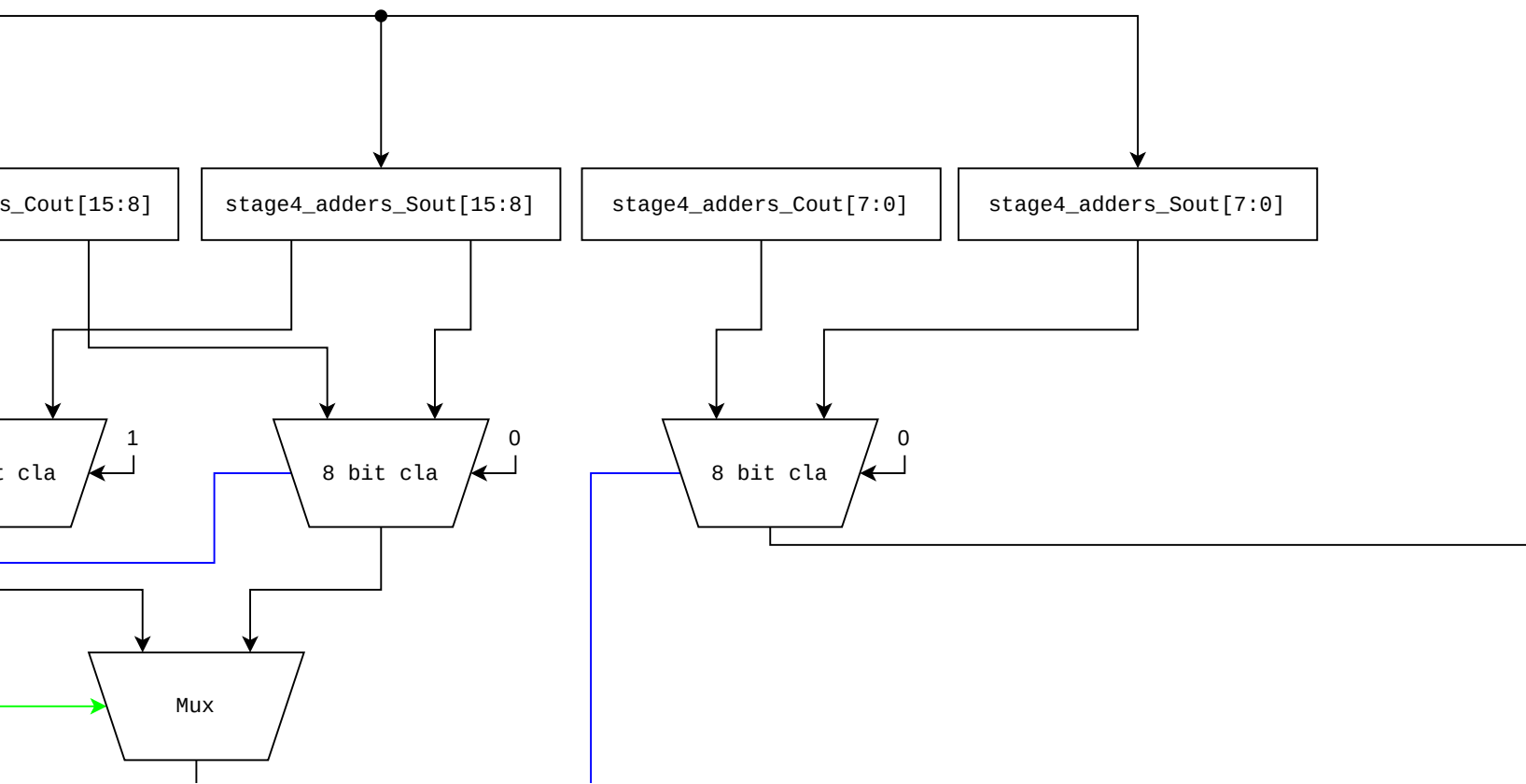
stage4_adder

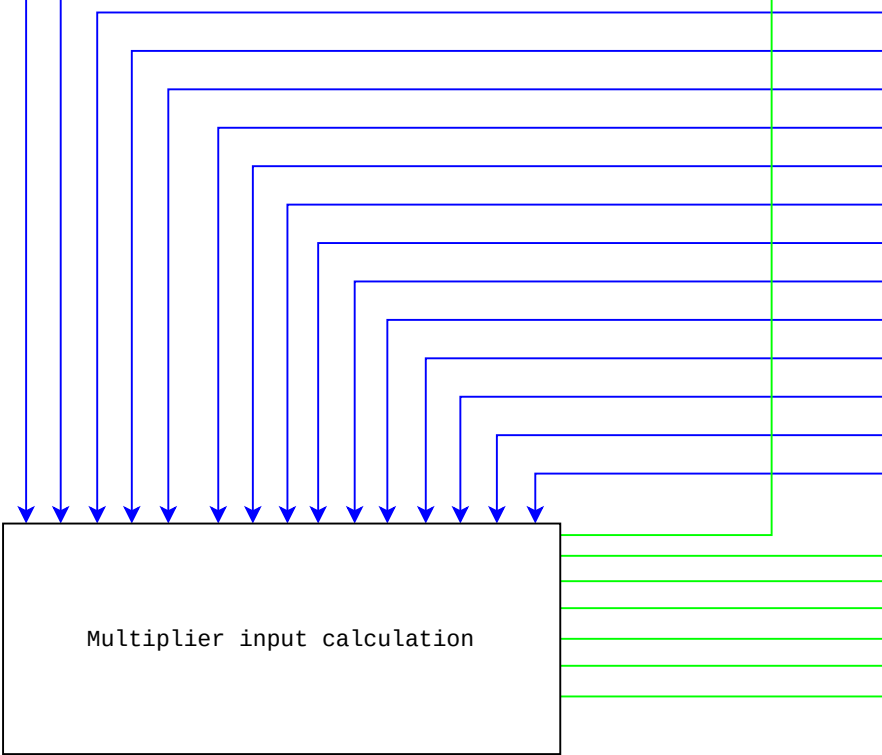












The diagram shows a 16x16 grid. The grid is composed of 16 columns and 16 rows. The grid is divided into four quadrants by a vertical black line at column 8 and a horizontal black line at row 8. The top-left quadrant (columns 1-8, rows 1-8) is outlined with blue lines. The top-right quadrant (columns 9-16, rows 1-8) is outlined with green lines. The bottom-left quadrant (columns 1-8, rows 9-16) is outlined with blue lines. The bottom-right quadrant (columns 9-16, rows 9-16) is outlined with green lines. The grid is further divided into four 8x8 sub-grids by the black lines. The top-left 8x8 sub-grid is outlined with blue lines. The top-right 8x8 sub-grid is outlined with green lines. The bottom-left 8x8 sub-grid is outlined with blue lines. The bottom-right 8x8 sub-grid is outlined with green lines. The grid is further divided into four 4x4 sub-grids by the black lines. The top-left 4x4 sub-grid is outlined with blue lines. The top-right 4x4 sub-grid is outlined with green lines. The bottom-left 4x4 sub-grid is outlined with blue lines. The bottom-right 4x4 sub-grid is outlined with green lines. The grid is further divided into four 2x2 sub-grids by the black lines. The top-left 2x2 sub-grid is outlined with blue lines. The top-right 2x2 sub-grid is outlined with green lines. The bottom-left 2x2 sub-grid is outlined with blue lines. The bottom-right 2x2 sub-grid is outlined with green lines. The grid is further divided into four 1x1 sub-grids by the black lines. The top-left 1x1 sub-grid is outlined with blue lines. The top-right 1x1 sub-grid is outlined with green lines. The bottom-left 1x1 sub-grid is outlined with blue lines. The bottom-right 1x1 sub-grid is outlined with green lines.

