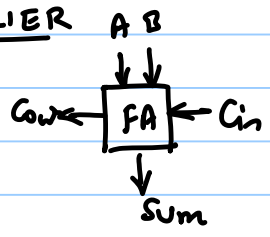
30/10/2019

EE5311

MODULE-6 - MULTIPLIERS

ARRAY MULTIPLIER



$x_3\ x_2\ x_1\ x_0$

$\times\ y_3\ y_2\ y_1\ y_0$

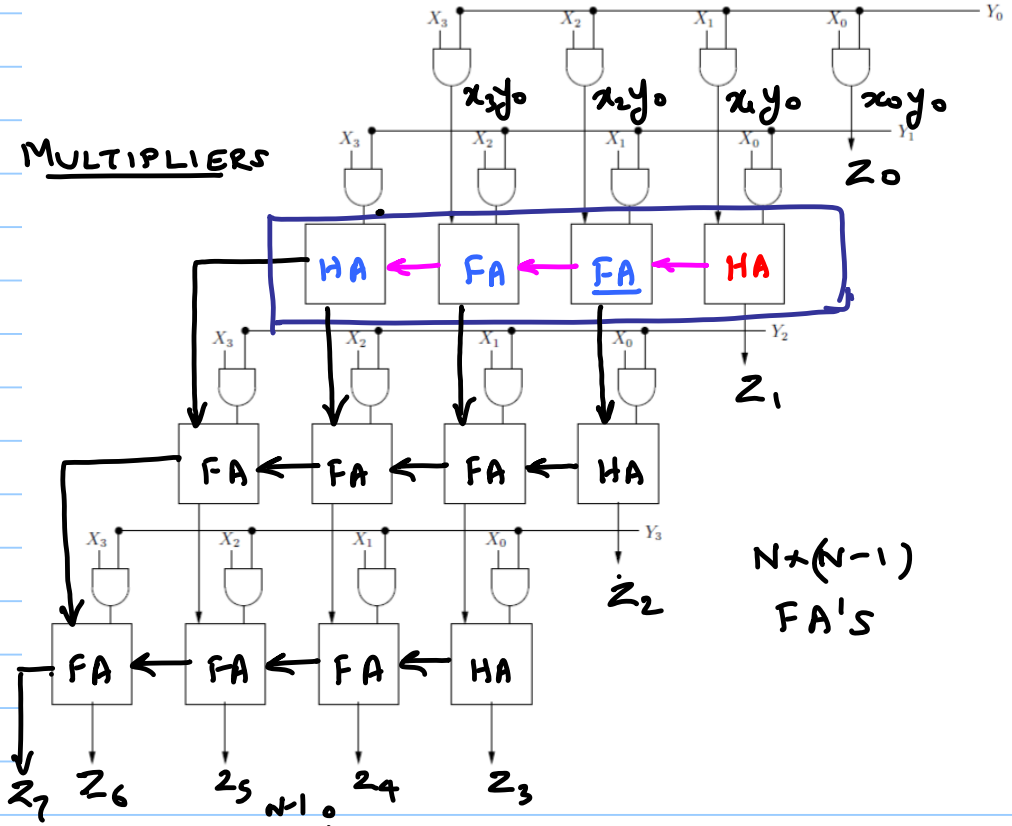
$x_3y_0\ \ x_2y_0\ \ x_1y_0\ \ x_0y_0$ — $\times y_0$

$x_3y_1\ \ x_2y_1\ \ x_1y_1\ \ x_0y_1$ — $2\times y_1$

$x_3y_2\ \ x_2y_2\ \ x_1y_2\ \ x_0y_2$ — $4\times y_2$

$x_3y_3\ \ x_2y_3\ \ x_1y_3\ \ x_0y_3$ — $8\times y_3$

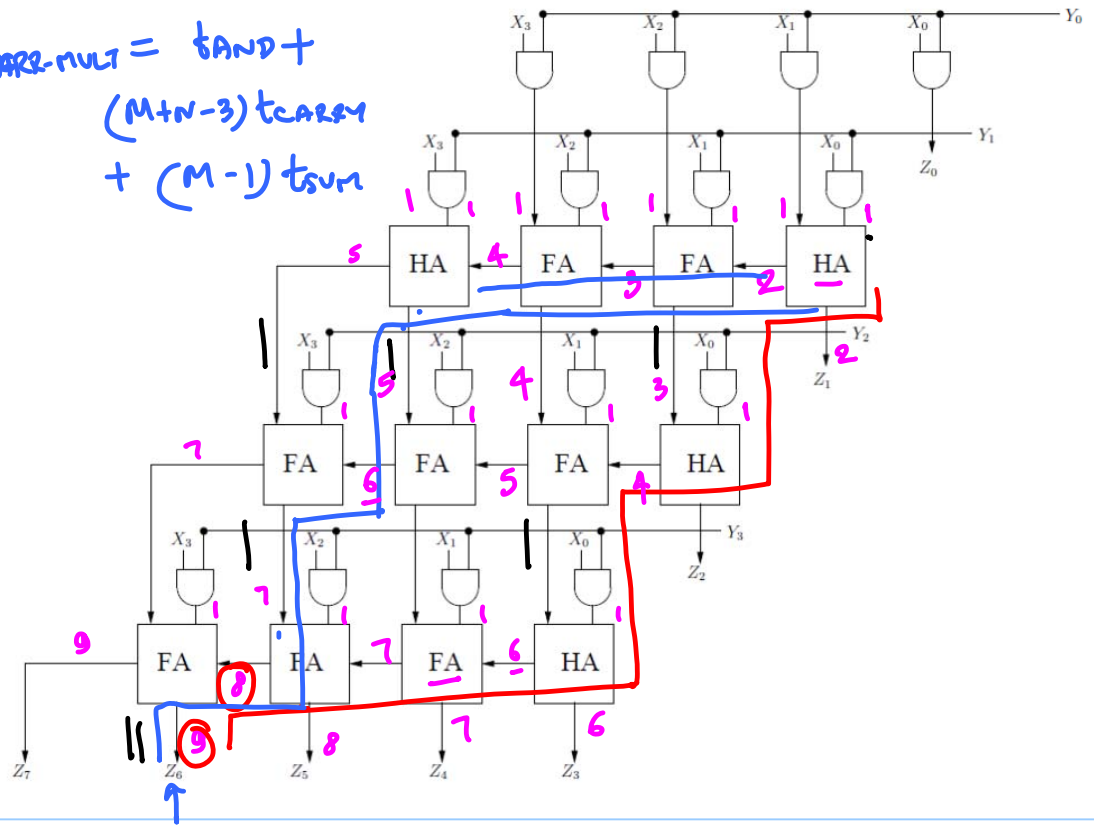
$z_7\ z_6\ z_5\ z_4\ z_3\ z_2\ z_1\ z_0$



$N\times(N-1)$ FA's

$$X \times Y = X \times \sum_{j=0}^{N-1} 2^j y_j = y_0 X + 2X y_1 + 4X y_2 + 8X y_3$$

$t_{ARR-MULT} = t_{AND} + (M+N-3)\,t_{CARRY} + (M-1)\,t_{SUM}$



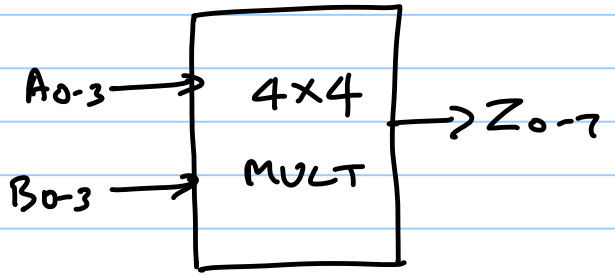
$t_{SUM} = 1 \rightarrow 2$

$t_{CARRY} = 1$

$t_{AND} = 1$

X_{0-3}, Y_{0-3} ARRIVAL TIME = 0

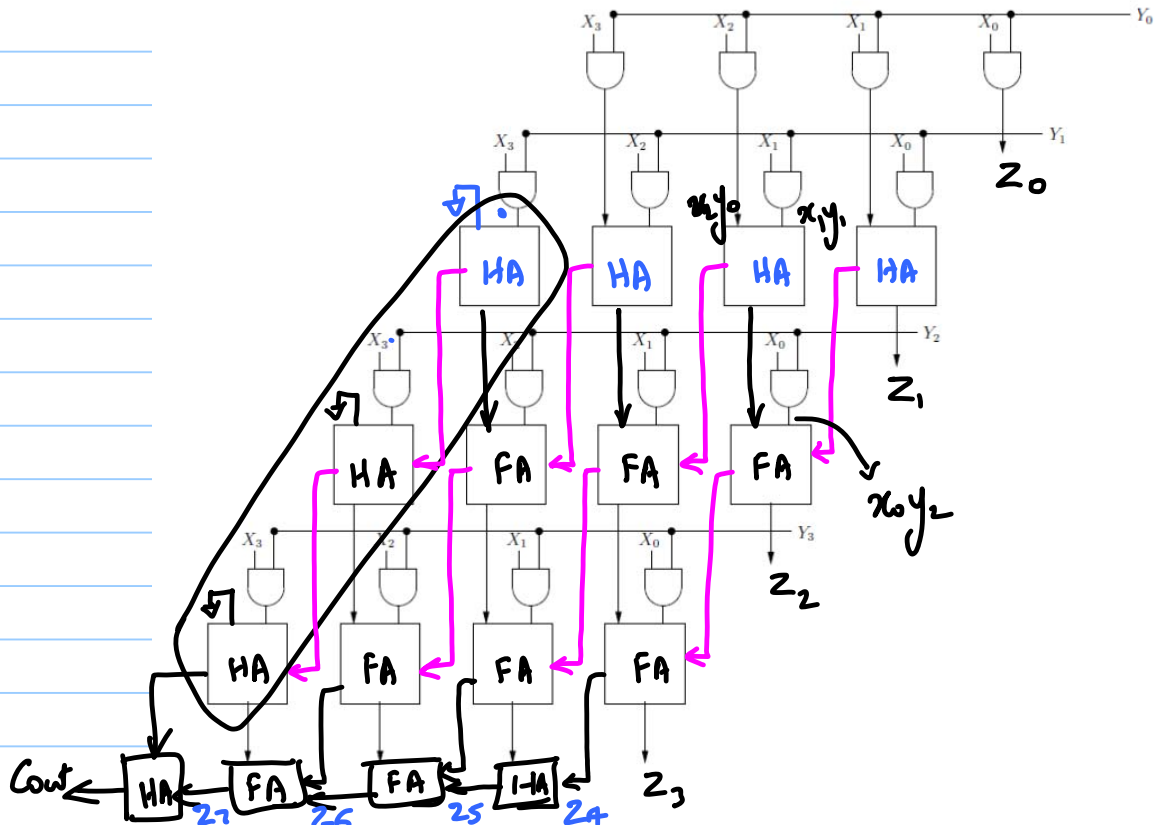
N BITS, M-BITS



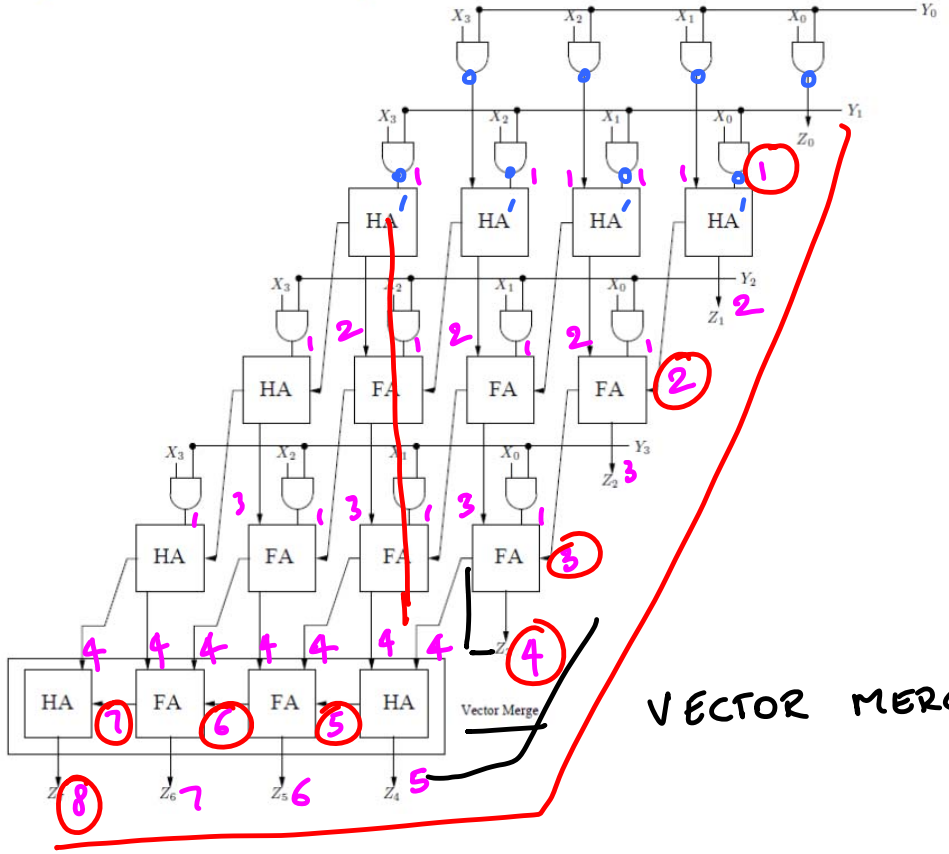
$t_{ARRAY-MULT} = t_{AND} + (N+M-2)\,t_{CAR} + (M-2)\,t_{SUM}$

$\rightarrow t_{AND} + (M-2+N-1)\,t_{CAR} + (M-1)\,t_{SUM}$

CARRY SAVE MULTIPLIER



Carry Save Multiplier Critical Path



VECTOR MERGE

$t_{AND} = 1$

$t_{SUM} = 1$

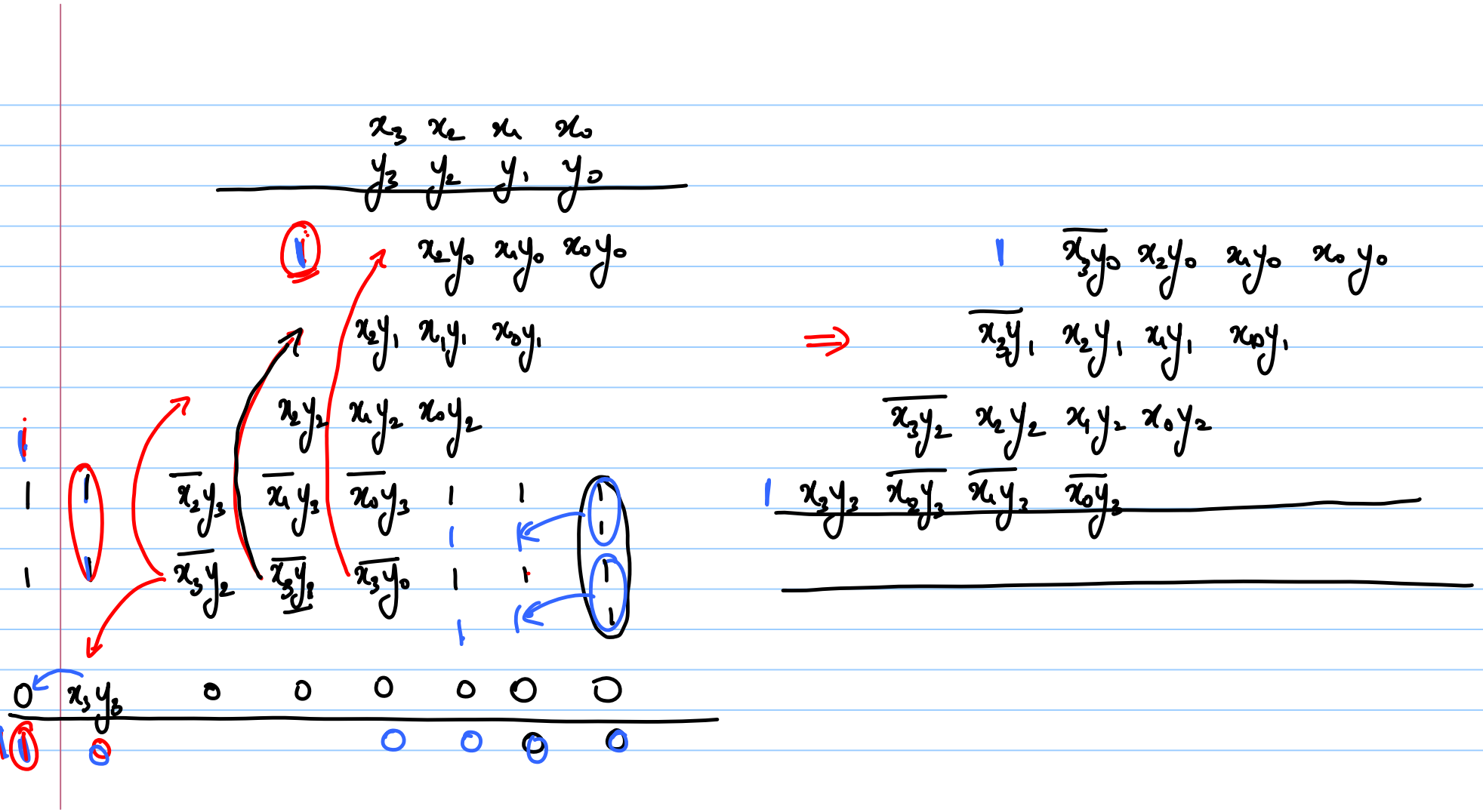
$t_{CARRY} = 1$

$$t_{CARRY\text{-}SAVE} = t_{AND} + (M-1)\,t_{SUM} + t_{MERGE}$$

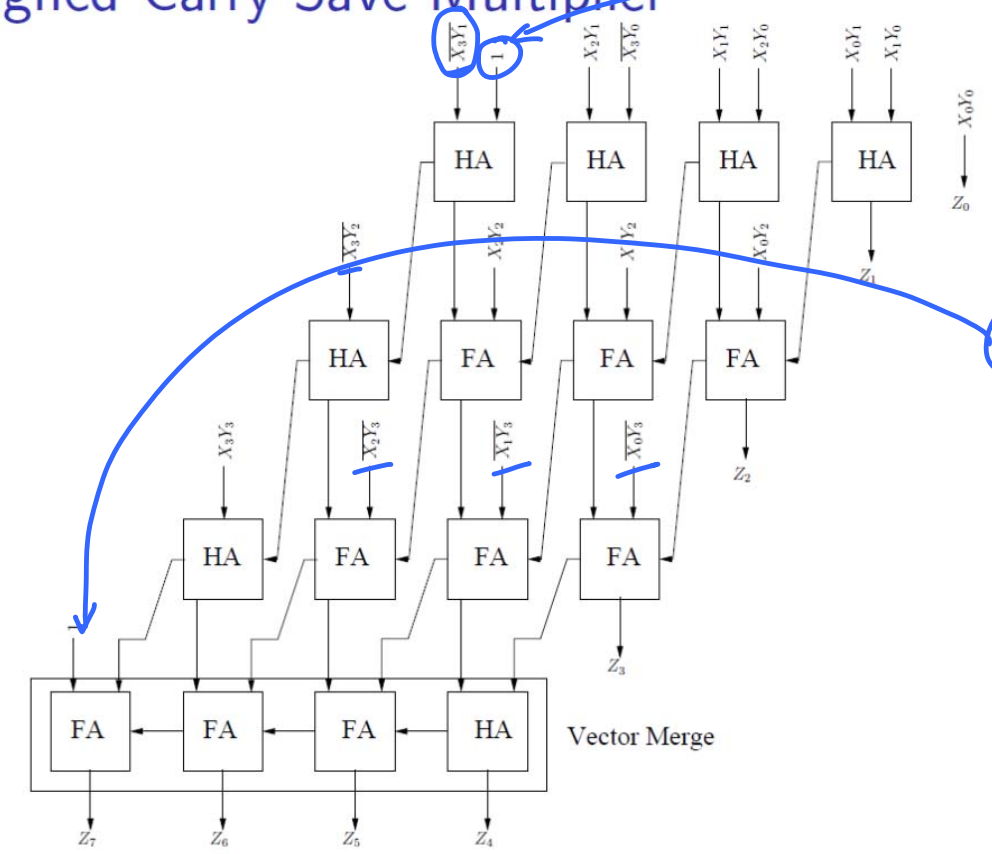
$$t_{MERGE} \rightarrow (N-1)\,t_{CARRY} + t_{SUM}$$

$$
\begin{array}{r}
x_3\ x_2\ x_1\ x_0 \\
\times\ y_3\ y_2\ y_1\ y_0 \\
\hline
x_3y_0\ \ x_2y_0\ \ x_1y_0\ \ x_0y_0 \\
x_3y_1\ \ x_2y_1\ \ x_1y_1\ \ x_0y_1
\end{array}
$$

$$
\begin{aligned}
z &= XY \\
&= \left(-2^{N-1}x_{N-1} + \sum_{i=0}^{N-2} x_i 2^i\right) \times \left(-2^{N-1}y_{N-1} + \sum_{j=0}^{N-2} y_j 2^j\right) \\
&= \underbrace{2^{(2N-2)}(x_{N-1}y_{N-1})} - \overbrace{2^{N-1}x_{N-1}\sum_{j=0}^{N-2} y_j 2^j} \\
&\quad \underbrace{- 2^{N-1}y_{N-1}\sum_{i=0}^{N-2} x_i 2^i} + \underbrace{\sum x_i 2^i \sum y_j 2^j}
\end{aligned}
$$


$x_3\ x_2\ x_1\ x_0$
$y_3\ y_2\ y_1\ y_0$
$x_2y_0\ x_1y_0\ x_0y_0$
$x_2y_1\ x_1y_1\ x_0y_1$
$x_2y_2\ x_1y_2\ x_0y_2$
$\overline{x_2}y_3\ \overline{x_1}y_3\ \overline{x_0}y_3$
$\overline{x_3}y_2\ \overline{x_3}y_1\ \overline{x_3}y_0$
x_3y_3
$\Rightarrow$
$\overline{x_3}y_0\ x_2y_0\ x_1y_0\ x_0y_0$
$\overline{x_3}y_1\ x_2y_1\ x_1y_1\ x_0y_1$
$\overline{x_3}y_2\ x_2y_2\ x_1y_2\ x_0y_2$
$x_3y_3\ \overline{x_2}y_3\ \overline{x_1}y_3\ \overline{x_0}y_3$

Signed Carry Save Multiplier



$$\overline{x_3y_0}\ x_2y_0\ x_1y_0\ x_0y_0$$

$$\overline{x_3y_1}\ x_2y_1\ x_1y_1\ x_0y_1$$

$$\overline{x_3y_2}\ x_2y_2\ x_1y_2\ x_0y_2$$

$$1\ \ x_3y_2\ \ \overline{x_2y_3}\ \ \overline{x_1y_2}\ \ \overline{x_0y_2}$$