

MPL & PWR - SEPARATE CHIP

$$+1_0 = m_0$$

$$-1_{12} = m_1 m_2 = P_2$$

$$+1_{12} = m_1 \bar{m}_2$$

$$+2_{12} = \bar{m}_1 m_2$$

$$-1_{34} = \bar{P}_2 m_3 m_4 + P_2 \bar{m}_3 m_4 = P_4$$

$$+1_{34} = \bar{P}_2 m_3 \bar{m}_4 + P_2 \bar{m}_3 \bar{m}_4$$

$$+2_{34} = \bar{P}_2 \bar{m}_3 m_4 + P_2 m_3 \bar{m}_4$$

$$-1_{56} = \bar{P}_4 m_5 m_6 + P_4 \bar{m}_5 m_6 = P_6$$

$$+1_{56} = \bar{P}_4 m_5 \bar{m}_6 + P_4 \bar{m}_5 \bar{m}_6$$

$$+2_{56} = \bar{P}_4 \bar{m}_5 m_6 + P_4 m_5 \bar{m}_6$$

$$+1_7 = \bar{P}_6 m_7 + P_6 \bar{m}_7$$

$$+2_7 = P_6 m_7$$

MULTIPLY CHIP

ar

POWER

(12) MPL's from MPL & PWR CHIP

(8) MCD's - two HEX digits from first and second neighbors to the left.

20 1-W

5 M

INGATING ($k=0,1,2,3$; d_{k+n} are multiplicand digits)

$$\alpha_{1,k} = +1_0 \cdot d_{k+8}$$

$$\sigma_{1,k} = -1_{12} \cdot d_{k+7} + +1_{12} \cdot d_{k+7} + +2_{12} \cdot d_{k+6}$$

$$\mathcal{H}_{1,k} = -1_{34} \cdot d_{k+5} + +1_{34} \cdot d_{k+5} + +2_{34} \cdot d_{k+4}$$

$$\mathcal{C}_{2,k} = -1_{56} \cdot d_{k+3} + +1_{56} \cdot d_{k+3} + +2_{56} \cdot d_{k+2}$$

$$\alpha_{3,k} = +1_7 \cdot d_{k+1} + +2_7 \cdot d_{k+0}$$

48 2-W

12 M

CARRY SAVE ADDERS ($i=1,2,3$; $k=0,1,2,3$)

$$\beta_{i+1,k} = \alpha_{i,k} \oplus \sigma_{i,k}$$

$$\sigma_{i+1,k} = \beta_{i+1,k} \oplus \mathcal{H}_{i,k} \quad (\text{sum})$$

$$\mathcal{H}_{i+1,k+1} = \alpha_{i,k} \cdot \sigma_{i,k} + \beta_{i+1,k} \cdot \mathcal{H}_{i,k} \quad (\text{carry})$$

72 2-W

18 M

LATCHES ($k=0,1,2,3$)

d_k

$\sigma_{4,k}$

18M+10³M $\mathcal{H}_{4,k+1}$

63M

9 log. lev. 9 ns

3 CHIP X 6 ns

1 LATCH 2 ns

ADDER CHIP

a_3

POWER

(8) OPS

10 1-w
2 1/2 M (2) SIGNAL

INGATING & COMPLEMENTING ($k=0,1,2,3$)

$$Q_k = A_{2Rk} \cdot SH_3 + A_{1Rk} \cdot SH_4 + A_k \cdot SH_0 + A_{1Lk} \cdot SH_4 + A_{2Lk} \cdot SH_8 + LD_A \cdot b_k$$

$$g_k = Q_{2Rk} \cdot SH_3 + Q_{1Rk} \cdot SH_4 + Q_k \cdot SH_0 + Q_{1Lk} \cdot SH_4 + Q_{2Lk} \cdot SH_8 + LD_Q \cdot g_k$$

$$\alpha_k = a_k \cdot \bar{C} + \bar{a}_k \cdot C$$

$$\sigma_k = \sigma_{1,k} \cdot M + g_k \cdot E$$

70 2-w
17 1/2 M $x_k = x_{4,k} \cdot M + D \cdot \bar{C} \quad (k=1,2)$

CARRY SAVE ADDER ($k=0,1,2,3$)

$$A_k = \alpha_k \oplus \sigma_k \oplus x_k$$

16 3-w
12 2-w
11 M $C_k = \alpha_k \cdot \sigma_k + \alpha_k \cdot x_k + \sigma_k \cdot x_k$

GROUP CARRY AND GROUP PROPAGATE ($k=0,1,2,3$)

$$S_k = A_k \oplus C_k$$

$$C_1 = A_0 \cdot C_0$$

$$C_2 = C_1 \cdot S_1 + A_1 \cdot C_1$$

$$C_3 = C_1 \cdot S_1 \cdot S_2 + A_1 \cdot C_1 \cdot S_2 + A_2 \cdot C_2$$

13 2-w
3 3-w
3 4-w
6 1/4 M $\begin{cases} C_4 = C_1 \cdot S_1 \cdot S_2 \cdot S_3 + A_1 \cdot C_1 \cdot S_2 \cdot S_3 + A_2 \cdot C_2 \cdot S_3 + A_3 \cdot C_3 \\ P = S_0 \cdot S_1 \cdot S_2 \cdot S_3 \end{cases}$

INTERNAL CARRY PROPAGATE ($k=1,2,3$)

$$S'_0 = S_0$$

6 2-w
1 1/2 M $S'_{k+1} = C_k \oplus S_k$

ADDER CHIP (CONT.)

24

IF CARRY IN (C_0) ($k=0,1,2,3$)

$$S_0'' = \bar{S}_0'$$

$$S_1'' = S_0' \cdot \bar{S}_1' + \bar{S}_0' \cdot S_1'$$

$$A_{01} = S_0' \cdot S_1'$$

$$A_{02} = \bar{S}_0' \cdot \bar{S}_1' \cdot S_2' = A_{01} \cdot S_2'$$

$$S_2'' = A_{01} \cdot \bar{S}_2' + \bar{A}_{01} \cdot S_2'$$

$$S_3'' = A_{02} \cdot \bar{S}_3' + \bar{A}_{02} \cdot S_3'$$

16 2-W
4 M $L_k = \bar{C}_0 \cdot S_k' + C_0 \cdot S_k''$

IF RECOMPLEMENT ($R = \bar{EAC}$) ($k=0,1,2,3$)

8 2-W
2 M $L_k' = R \oplus L_k$

IF DECIMAL CORRECTION (δ)

$$E = C_4 + P \cdot C_0$$

$$\gamma = \bar{C} + C \cdot \bar{R}$$

$$\delta = \bar{E} \cdot \gamma \cdot D + E \cdot C \cdot R \cdot D$$

$$L_0'' = L_0'$$

$$L_1'' = \delta \cdot \bar{L}_1' + \bar{\delta} \cdot L_1'$$

2 1-W
6 2-W $L_2'' = \delta \cdot \bar{L}_1' \cdot \bar{L}_2' + \delta \cdot \bar{L}_1' \cdot L_2' + \bar{\delta} \cdot L_2'$

5 3-W
2 4-W $L_3'' = \delta \cdot \bar{L}_1' \cdot \bar{L}_2' \cdot \bar{L}_3' + \delta \cdot \bar{L}_1' \cdot \bar{L}_2' \cdot L_3' + \delta \cdot \bar{L}_1' \cdot L_2' \cdot \bar{L}_3' + \bar{\delta} \cdot L_3'$

5 1/2 M LATCHES ($k=0,1,2,3$)

12M+10M A_k
 Q_k

73 M	12 Log. Lev.	12 ns
	3 CHIP X	6 ns
	1 LATCH	2 ns
		<u>20 ns</u>

MPL & PWR - SEPARATE CHIP

b₁

$$+l_0 = m_0$$

$$-l_{12} = m_1 \cdot m_2 = P_2$$

$$+l_{12} = m_1 \cdot \overline{m}_2$$

$$+2_{12} = \overline{m}_1 \cdot m_2$$

$$+l_3 = \overline{P}_2 \cdot m_3 + P_2 \cdot \overline{m}_3$$

$$+2_3 = P_2 \cdot m_3$$

MULTIPLY-ADD CHIP

b₂

POWER

(6) MPL's from MPL & PWR CHIP

(4) MCD's - HEX digit from left neighbor

(8) OPS

20 I-W

5 M

(2) SIGNAL

INGATING 1 ($k=0,1,2,3$; d_{k+n} are multiplicand digits)

$$\alpha_{1,k} = +1_0 \cdot d_{k+4}$$

$$24 \text{ 2-W } \sigma_{1,k} = -1_{12} \cdot d_{k+3} + +1_{12} \cdot d_{k+3} + +2_{12} \cdot d_{k+2}$$

$$6 \text{ M } \gamma_{1,k} = +1_5 \cdot d_{k+1} + +2_5 \cdot d_{k+0}$$

CARRY SAVE ADDER 1 ($k=0,1,2,3$)

$$\beta_{2,k} = \alpha_{1,k} \oplus \sigma_{1,k}$$

$$24 \text{ 2-W } \sigma_{2,k} = \beta_{2,k} \oplus \gamma_{2,k} \quad (\text{sum})$$

$$6 \text{ M } \gamma_{2,k+1} = \alpha_{1,k} \cdot \sigma_{1,k} + \beta_{2,k} \cdot \gamma_{1,k} \quad (\text{carry})$$

INGATING 2 & COMPLEMENTING ($k=0,1,2,3$)

$$a_k = A_{Rk} \cdot SH_{14} + A_k \cdot SH_0 + A_{Lk} \cdot SH_{14} + LD_A \cdot b_k$$

$$g_k = Q_{Rk} \cdot SH_{14} + Q_k \cdot SH_0 + Q_{Lk} \cdot SH_{14} + LD_Q \cdot g_k$$

$$\alpha_k = a_k \cdot \bar{C} + \bar{a}_k \cdot C$$

$$54 \text{ 2-W } \sigma_k = \sigma_{2,k} \cdot M + g_k \cdot E$$

$$13 \frac{1}{2} \text{ M } \gamma_k = \gamma_{2,k} \cdot M + D \cdot \bar{C} \quad (k=1,2)$$

CARRY SAVE ADDER 2 ($k=0,1,2,3$)

$$\sigma'_k = \alpha_k \oplus \sigma_k$$

$$24 \text{ 2-W } \Delta_k = \sigma'_k \oplus \gamma_k$$

6 M

$$C_k = \alpha_k \cdot \sigma_k + \sigma'_k \cdot \gamma_k$$

GROUP CARRY & GROUP PROPAGATE ($k=0,1,2,3$)

$$S_k = \Delta_k \oplus C_k$$

$$C_1 = b_0 \cdot C_0$$

$$C_2 = C_1 \cdot S_1 + b_1 \cdot C_1$$

$$C_3 = C_1 \cdot S_1 \cdot S_2 + b_1 \cdot C_1 \cdot S_2 + b_2 \cdot C_2$$

13 2-W

3 3-W

3 4-W

2 " "

$$\{C_4 = C_1 \cdot S_1 \cdot S_2 \cdot S_3 + b_1 \cdot C_1 \cdot S_2 \cdot S_3 + b_2 \cdot C_2 \cdot S_3 + b_3 \cdot C_3\}$$

MULTIPLY-ADD CHIP (CONT.)

INTERNAL CARRY PROPAGATE ($k=1,2,3$)

$$\begin{array}{l} 6 \text{ 2-W} \\ 1\frac{1}{2} \text{ M} \end{array} \quad \begin{array}{l} S'_0 = S_0 \\ S'_{k+0} = C_k \oplus S_k \end{array}$$

IF CARRY IN (C_0) ($k=0,1,2,3$)

$$\begin{array}{l} 16 \text{ 2-W} \\ 4 \text{ M} \end{array} \quad \begin{array}{l} S''_0 = \bar{S}'_0 \\ S''_1 = S'_0 \cdot \bar{S}'_1 + \bar{S}'_0 \cdot S'_1 \\ A_{01} = S'_0 \cdot S'_1 \\ A_{02} = A_{01} \cdot S'_2 \\ S''_2 = A_{01} \cdot \bar{S}'_2 + \bar{A}_{01} \cdot S'_2 \\ S''_3 = A_{02} \cdot \bar{S}'_3 + \bar{A}_{02} \cdot S'_3 \\ S_k = \bar{C}_0 \cdot S'_k + C_0 \cdot S''_k \end{array}$$

IF RECOMPLEMENT ($R = \overline{EAC}$) ($k=0,1,2,3$)

$$\begin{array}{l} 8 \text{ 2-W} \\ 2 \text{ M} \end{array} \quad S'_k = R \oplus S_k$$

IF DECIMAL CORRECTION (δ)

$$\begin{array}{l} 2 \text{ 1-W} \\ 6 \text{ 2-W} \\ 5 \text{ 3-W} \\ 2 \text{ 4-W} \\ 5\frac{1}{2} \text{ M} \end{array} \quad \begin{array}{l} E = C_4 + P \cdot C_0 \\ \gamma = \bar{C} + C \cdot \bar{R} \\ \delta = \bar{E} \cdot \gamma \cdot D + E \cdot C \cdot R \cdot D \\ S''_0 = S'_0 \\ S''_1 = \delta \cdot \bar{S}'_1 + \bar{\delta} \cdot S'_1 \\ S''_2 = \delta \cdot \bar{S}'_1 \cdot \bar{S}'_2 + \delta \cdot \bar{S}'_1 \cdot S'_2 + \bar{\delta} \cdot S'_2 \\ S''_3 = \delta \cdot \bar{S}'_1 \cdot \bar{S}'_2 \cdot \bar{S}'_3 + \delta \cdot \bar{S}'_1 \cdot \bar{S}'_2 \cdot S'_3 + \delta \cdot \bar{S}'_1 \cdot S'_2 \cdot \bar{S}'_3 + \bar{\delta} \cdot S'_3 \end{array}$$

LATCHES ($k=0,1,2,3$)

$$\begin{array}{l} 18 \text{ M} + 10 \text{ M} \end{array} \quad \begin{array}{l} d_k \\ A_k \\ Q_k \end{array}$$

$$\begin{array}{l} 84 \text{ M} \end{array} \quad \begin{array}{l} 16 \text{ Log. Lev. } 16 \text{ ns} \\ 5 \text{ CHIP X } 10 \text{ ns} \\ 1 \text{ LATCH } 2 \text{ ns} \\ \hline 28 \text{ ns} \end{array}$$