

**SP1: EXECUTION STEPS FOR AREA OPTIMIZED ADDITION WITHIN
CONVENTIONAL MEMORY CROSSBAR**

Cycle #	Goal	Logic Operation	V₀	GND
1	Initialization	$M_4, M_5 \dots M_9 = R_{ON}$	-	-
2	Execution of C_{out}	$M_4 = (A + B)'$	V ₁ , V ₂	V ₄
3		$M_5 = (B + C)'$	V ₂ , V ₃	V ₅
4		$M_6 = (C + A)'$	V ₁ , V ₃	V ₆
5		$M_7 = C_{out} = ((A + B)' + (B + C)' + (C + A)')'$	V ₄ , V ₅ , V ₆	V ₇
6		$M_4, M_5, M_6 = R_{ON}$	-	-
7	Execution of S	$M_4 = A'$	V ₁	V ₄
8		$M_5 = B'$	V ₂	V ₅
9		$M_6 = C'$	V ₃	V ₆
10		$M_8 = (A' + B' + C)'$	V ₄ , V ₅ , V ₆	V ₈
11		$M_9 = (A + B + C)'$	V ₁ , V ₂ , V ₃	V ₉
12		$M_4, M_5, M_6 = R_{ON}$	-	-
13		$M_4 = (C_{out} + (A + B + C)')'$	V ₇ , V ₉	V ₄
14		$M_5 = S' = ((A' + B' + C)')' + (C_{out} + (A + B + C)')'$	V ₄ , V ₈	V ₅
15		$M_6 = S = (A' + B' + C)')' + (C_{out} + (A + B + C)')'$	V ₅	V ₆

**SP2: EXECUTION STEPS FOR LATENCY OPTIMIZED ADDITION WITHIN
CONVENTIONAL MEMORY CROSSBAR**

Cycle #	Goal	Logic Operation	V₀	GND
1	Initialization	$M_4, M_5 \dots M_{15} = R_{ON}$	-	-
2	Execution of C_{out}	$M_4 = (A + B)'$	V ₁ , V ₂	V ₄
3		$M_5 = (B + C)'$	V ₂ , V ₃	V ₅
4		$M_6 = (C + A)'$	V ₁ , V ₃	V ₆
5		$M_7 = C_{out} = ((A + B)' + (B + C)' + (C + A)')'$	V ₄ , V ₅ , V ₆	V ₇
6		Execution of S	$M_8 = A'$	V ₁
7	$M_9 = B'$		V ₂	V ₉
8	$M_{10} = C'$		V ₃	V ₁₀
9	$M_{11} = (A' + B' + C)'$		V ₈ , V ₉ , V ₁₀	V ₁₁
10	$M_{12} = (A + B + C)'$		V ₁ , V ₂ , V ₃	V ₁₂
11	$M_{13} = (C_{out} + (A + B + C)')'$		V ₇ , V ₁₂	V ₁₃
12	$M_{14} = S' = ((A' + B' + C)')' + (C_{out} + (A + B + C)')'$		V ₁₁ , V ₁₃	V ₁₄
13	$M_{15} = S = (A' + B' + C)')' + (C_{out} + (A + B + C)')'$		V ₁₄	V ₁₅

SP3: EQUIVALENT LOGICAL OPERATIONS AND APPLICATIONS OF VOLTAGES IN EACH CYCLE WHILE EXECUTING ADDER ON TRANSPOSE MEMORY USING SCHEME-1

Cycle #	Goal	Logic Operation	V ₀	GND	V _{HS}	V _{VS}
1	Initialization	$M_{x,y}^1 = R_{ON}, x \in \{1, 4\}, y \in \{2, 7\}$	-	-	-	-
2	Execute part of S	$M_{1,4} = A'$ $M_{2,4} = B'$ $M_{3,4} = C'$	V ₁	V ₄	H ₄	-
3	Copy A~ to M _{3,2}	$M_{1,5} = A$	V ₄	V ₅	H _{1, H2, H3}	-
4		$M_{3,5} = A'$	H ₃	H ₁	-	V _{1, V2, V3, V4, V6, V7}
5		$M_{3,2} = A$	V ₅	V ₂	H _{1, H2, H4}	-
6	Copy B~ to M _{1,2}	$M_{2,6} = B$	V ₄	V ₆	H _{1, H3, H4}	-
7		$M_{1,6} = B'$	H ₁	H ₂	-	V _{1, V2, V3, V4, V5, V7}
8		$M_{1,2} = B$	V ₆	V ₂	H _{2, H3, H4}	-
9	Copy C~ to M _{2,2}	$M_{3,7} = C$	V ₄	V ₇	H _{1, H2, H4}	-
10		$M_{2,7} = C'$	H ₂	H ₃	-	V _{1, V2, V3, V4, V5, V6}
11		$M_{2,2} = C$	V ₇	V ₂	H _{1, H3, H4}	-
12	Execute part of C _{out}	$M_{1,3} = (A + B)'$ $M_{2,3} = (B + C)'$ $M_{3,3} = (C + A)'$	V _{1, V2}	V ₃	H ₄	-
13	Execute C _{out} and part of S	$M_{4,3} = C_{out} = ((A + B)' + (B + C)' + (C + A)')'$ $M_{4,2} = (A + B + C)'$ $M_{4,4} = (A' + B' + C)'$	H ₄	H _{1, H2, H3}	-	V _{1, V5, V6, V7}
14	Finish S execution	$M_{4,5} = (C_{out} + (A + B + C)')'$	V _{2, V3}	V ₅	H _{1, H2, H3}	-
15		$M_{4,6} = S' = ((A' + B' + C)')' + (C_{out} + (A + B + C)')'$	V _{4, V5}	V ₆	H _{1, H2, H3}	-
16		$M_{4,7} = S = (A' + B' + C)')' + (C_{out} + (A + B + C)')'$	V _{5, V6}	V ₇	H _{1, H2, H3}	-

¹ $M_{x,y} \in \{M_{1,2}, M_{1,3}, M_{1,4}, M_{1,5}, M_{1,6}, M_{1,7}, M_{2,2}, M_{2,3}, M_{2,4}, M_{2,5}, M_{2,6}, M_{2,7}, M_{3,2}, M_{3,3}, M_{3,4}, M_{3,5}, M_{3,6}, M_{3,7}, M_{4,2}, M_{4,3}, M_{4,4}, M_{4,5}, M_{4,6}, M_{4,7}\}$

SP4: EQUIVALENT LOGICAL OPERATIONS AND APPLICATIONS OF VOLTAGES IN EACH CYCLE WHILE EXECUTING ADDER ON TRANSPOSE MEMORY USING SCHEME-2

Cycle #	Goal	Logic Operation	V ₀	GND	V _{HS}	V _{VS}
1	Initialization	$M_{1,4}, M_{1,5} \dots M_{1,9} = R_{ON}$	-	-	-	-
2		$M_{2,1}, M_{2,2}, M_{2,3}, M_{2,9} = R_{ON}$	-	-	-	-
3		$M_{3,9}, M_{4,9} = R_{ON}$	-	-	-	-
4	Execution of C_{out}	$M_{1,4} = (A + B)'$	V ₁ , V ₂	V ₄	H ₂ , H ₃ , H ₄	-
5		$M_{1,5} = (B + C)'$	V ₂ , V ₃	V ₅	H ₂ , H ₃ , H ₄	-
6		$M_{1,6} = (C + A)'$	V ₁ , V ₃	V ₆	H ₂ , H ₃ , H ₄	-
7		$M_{1,7} = C_{out} = ((A + B)') + (B + C)' + (C + A)'$	V ₄ , V ₅ , V ₆	V ₇	H ₂ , H ₃ , H ₄	-
8	Execution of S	$M_{1,8} = (A + B + C)'$	V ₁ , V ₂ , V ₃	V ₈	H ₂ , H ₃ , H ₄	-
9		$M_{1,9} = (C_{out} + (A + B + C)')'$	V ₇ , V ₈	V ₉	H ₂ , H ₃ , H ₄	-
10		$M_{2,1} = A'$ $M_{2,2} = B'$ $M_{2,3} = C'$	H ₂	H ₁	-	V ₄ , V ₅ , V ₆ , V ₇ , V ₈ , V ₉
11		$M_{2,9} = (A' + B' + C)'$	V ₁ , V ₂ , V ₃	V ₉	H ₁ , H ₃ , H ₄	-
12		$M_{3,9} = S' = ((A' + B' + C)') + (C_{out} + (A + B + C)')'$	H ₃	H ₁ , H ₂	-	V ₁ , V ₂ , V ₃ , V ₄ , V ₅ , V ₆ , V ₇ , V ₈
13		$M_{4,9} = S = (A' + B' + C) + (C_{out} + (A + B + C)')$	H ₄	H ₂	-	V ₁ , V ₂ , V ₃ , V ₄ , V ₅ , V ₆ , V ₇ , V ₈