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A Current-Based 12T XNOR SRAM Compute-In-Memory (CIM) Macro For Binary/Ternary Deep Neural Networks

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Objective/Background

Develop a XNOR SRAM based CIM Macro Featuring Current-Based XNOR Accumulation for Binary/Ternary DNNs

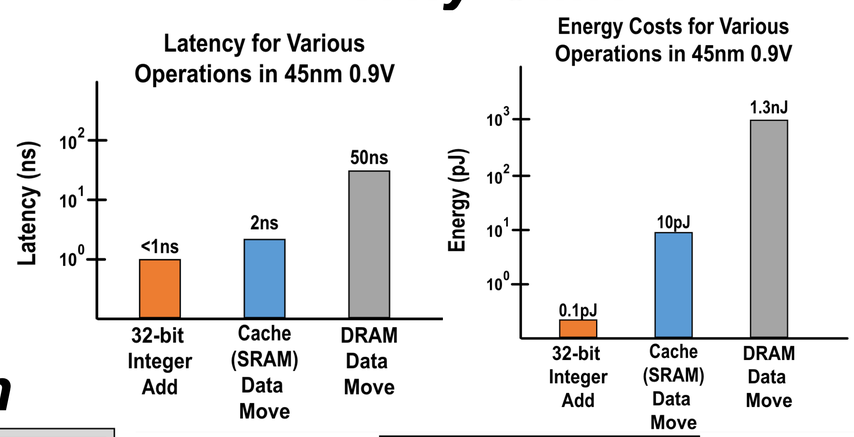
BNN

$$x^b = Sign(x) = \begin{cases} +1 & if\ x \geq 0 \\ -1 & otherwise \end{cases}$$

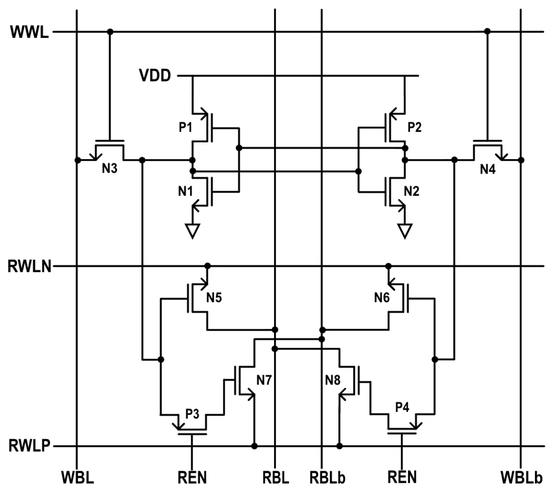
TBN

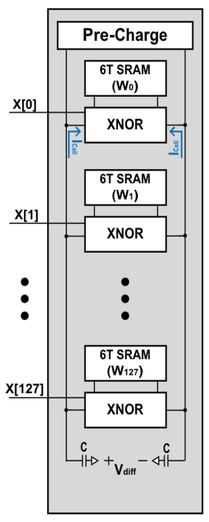
$$T_i = f_{ternary}(I_i, \Delta) = \begin{cases} +1, & I_i > \Delta; \\ 0, & |I_i| \leq \Delta; \\ -1, & I_i < -\Delta; \end{cases}$$

Why CIM?

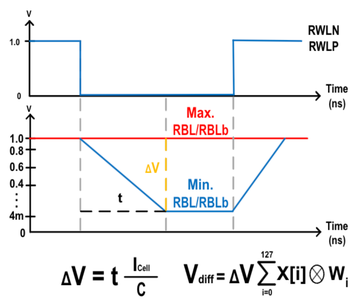


Methodology

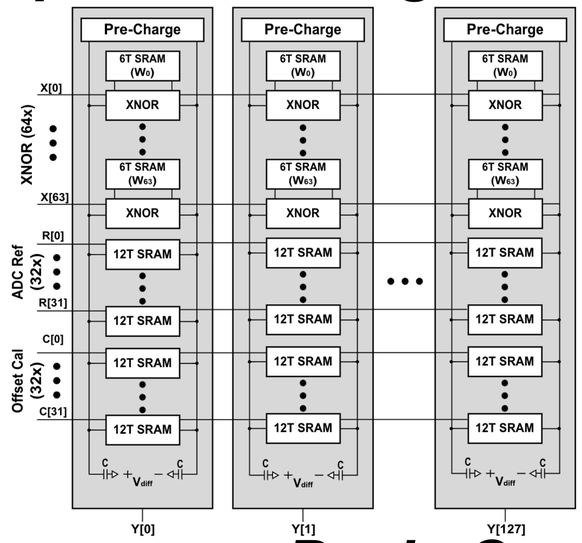


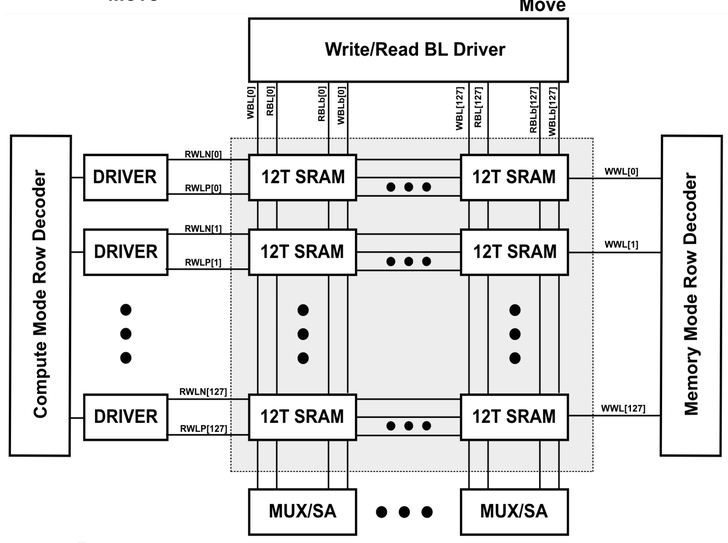


Bottom-Up Block Design



$$\Delta V = t\frac{I_{Cell}}{C} \qquad V_{diff} = \Delta V \sum_{i=0}^{127} X[i] \otimes W_i$$

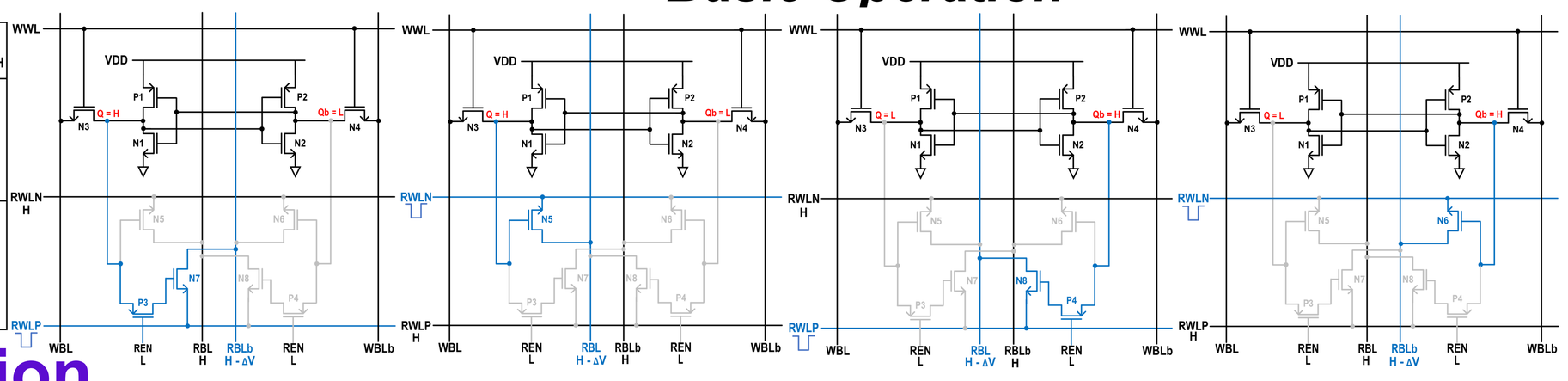




Logic Table

Input / Weight	-1 (RWLN = H, RWLP = ⊓)	0 (RWLN = H, RWLN = H)	+1 (RWLN = ⊓, RWLP = H)
-1 (Q=H, Qb=L)	+1 (+ ΔV)	0 No Change	-1 (- ΔV)
+1 (Q=L, Qb=H)	-1 (- ΔV)	0 No Change	+1 (+ ΔV)

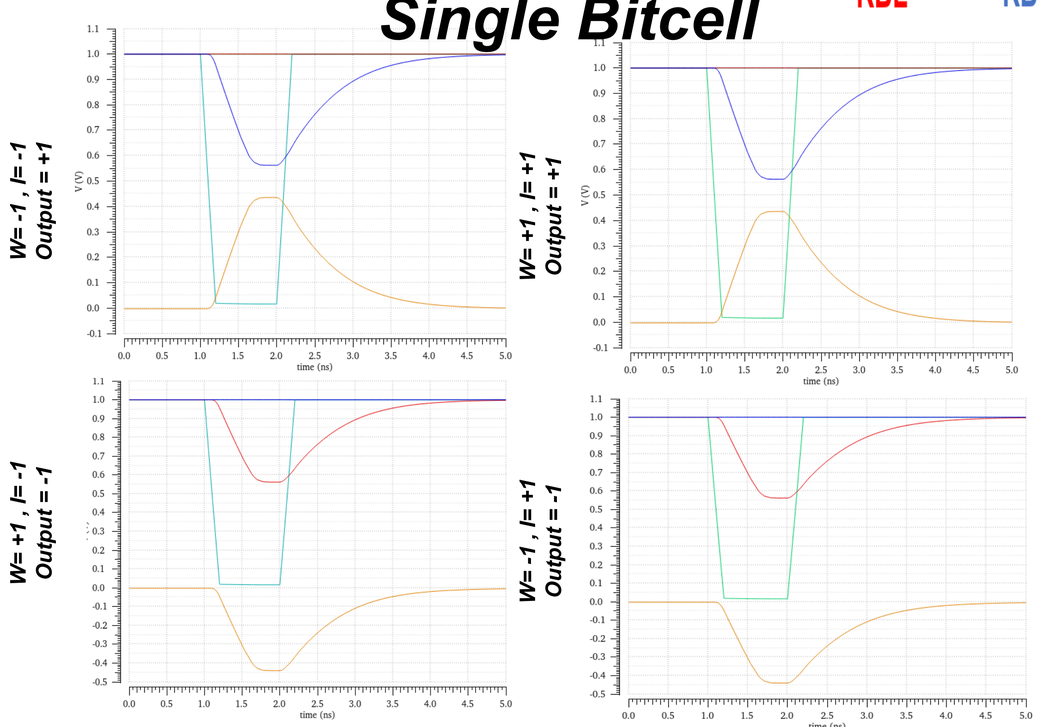
Basic Operation



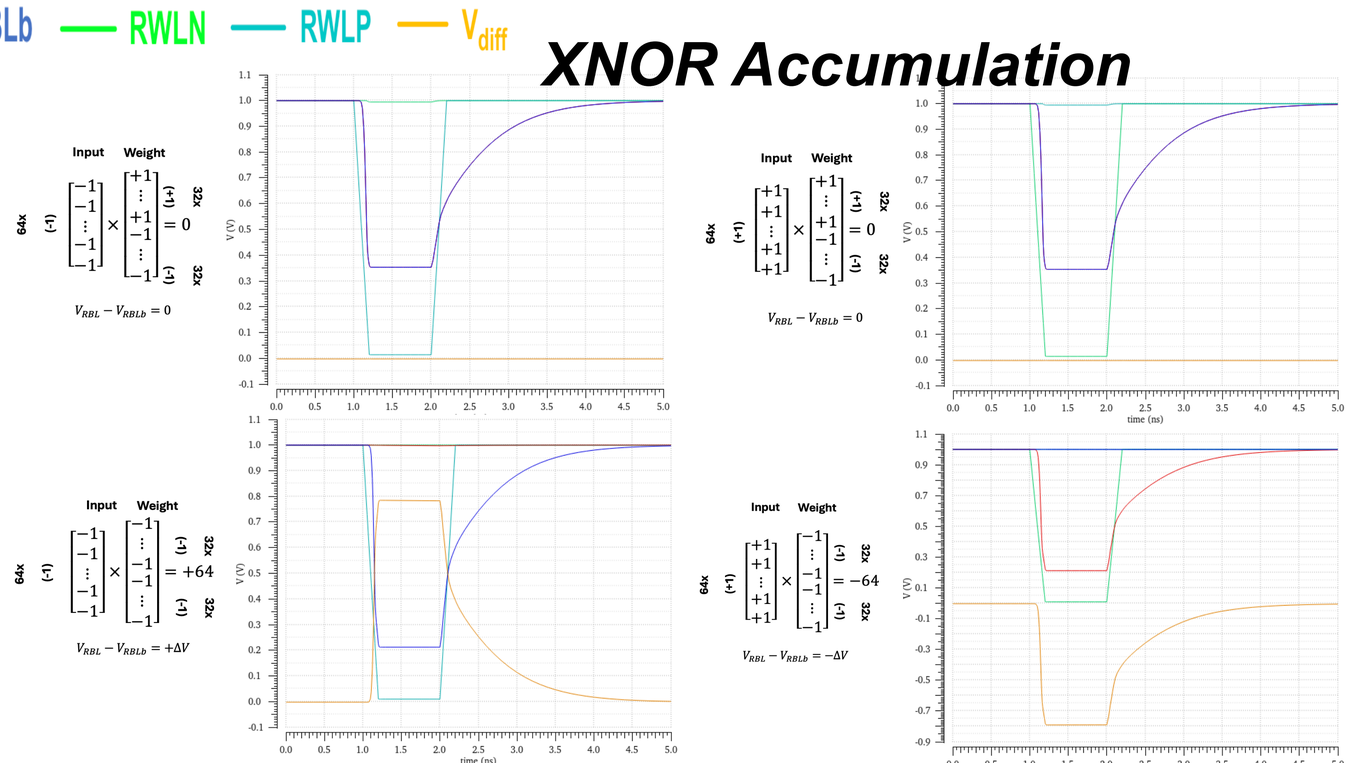
Results/Application

Single Bitcell

RBL RBLb RWLN RWLP V_{diff}



XNOR Accumulation



Overall Structure