Topic

Matrix Multiplication

BY

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OVERVIEW

In the Trivial Matrix multiplication approach, consider two 3x3 matrix,

$$A = \begin{matrix} 0 & 1 & 2 \\ 3 & 4 & 5 \\ 6 & 7 & 8 \end{matrix} \qquad B = \begin{matrix} 0 & 1 & 2 \\ 3 & 4 & 5 \\ 6 & 7 & 8 \end{matrix}$$

The resultant matrix would be a 3x3 matrix too,

As, P x Q R x S

3 x 3 3 x 3

- Q should be equal to R
- Then the resultant matrix is P x S

The resultant matrix is

$$\text{Result} = \begin{matrix} 15 & 18 & 21 \\ 42 & 54 & 66 \\ 69 & 90 & 111 \end{matrix}$$

to calculate first element: (0x0) + (1x3) + (2x6) =15

Till 9th element

Each value calculation needs Q = R number of additions and Q = R number of multiplication
Hence in the trivial algorithm, the clock cycles needed to calculate the result value is 3 Clock Cycles, So it will take 3 Cycles x 9 values = 27 Clock cycles to find the resultant matrix

The approach I came up with can solve the matrix in just 9 Clock Cycles for the same example by using a pipelining of the matrix multiplication

In the algorithim I propose has one restriction i.e
If A is a P x Q matrix,
B is a R x **S** matrix,
For computing Mat_A x Mat_B ; **S** should be a equal to 3 or a multiple of 3 (3,9,12…..);

Note: S (multiple of 3) value in the algorithm is a factor and can me changed to a different factor depending on the resource utilization of the FPGA and can be made to any factor by doing minor change in the algorithm

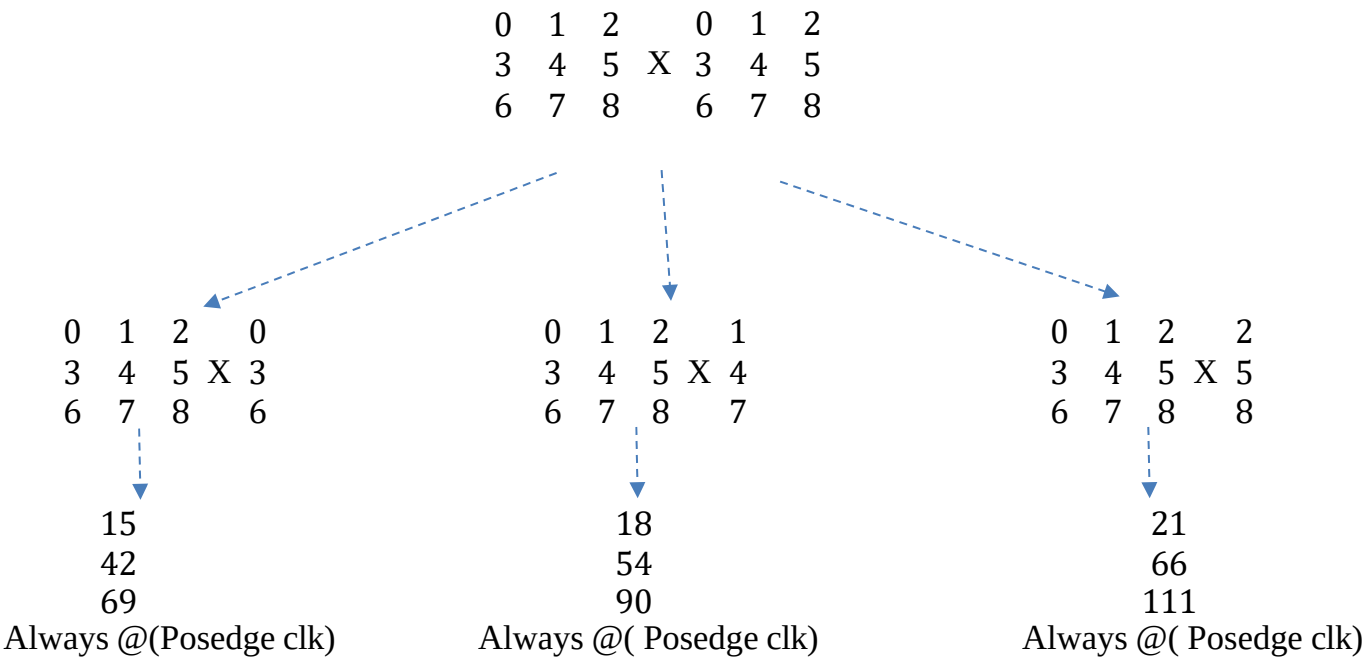
WORKING

Consider the same example,

$$A=\begin{matrix}0&1&2\\3&4&5\\6&7&8\end{matrix} \qquad B=\begin{matrix}0&1&2\\3&4&5\\6&7&8\end{matrix}$$

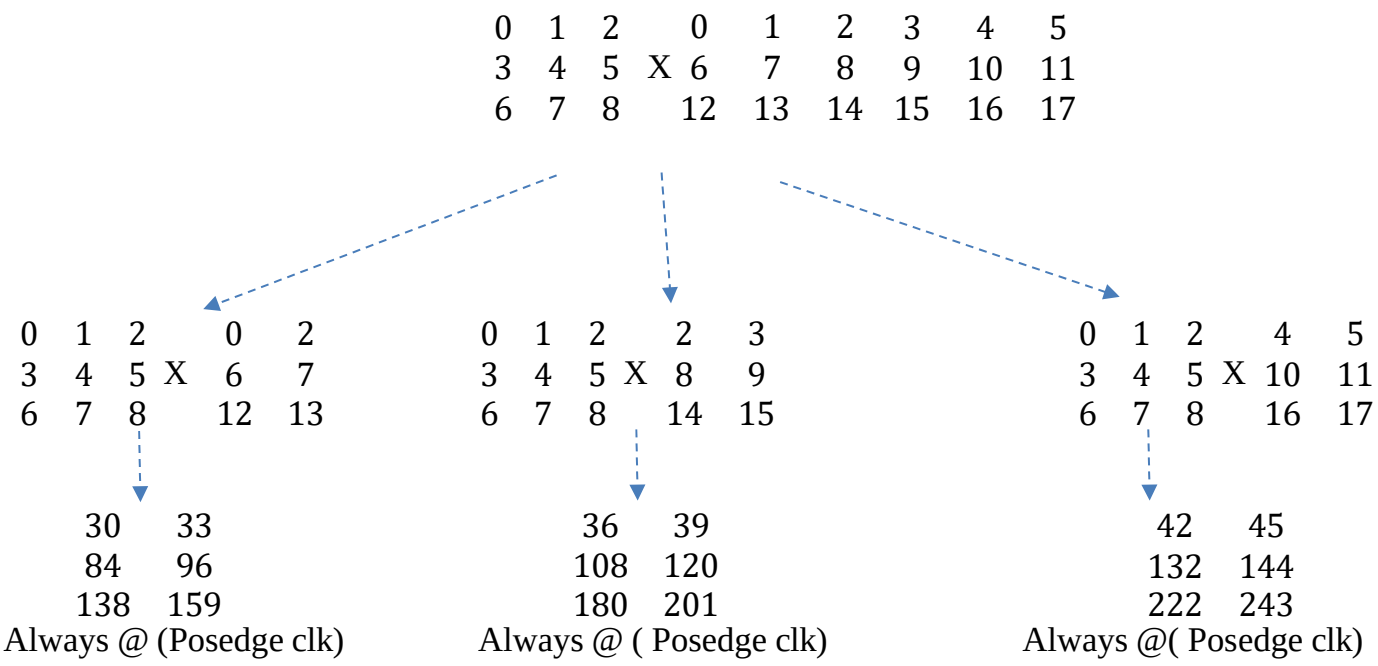
In the algorithm there are three Always blocks; it is observed that the calculation of the resultant of each element is independent to other elements calculated.

The matrix B can be sliced into 3 (**S=3**) matrices along the column to make it a 3 x 1 matrix,
It is sliced such a way that the first column of the Matrix B is taken care by first always block,
the second column is taken care by the second always block,
the third column is taken care by the third always block,

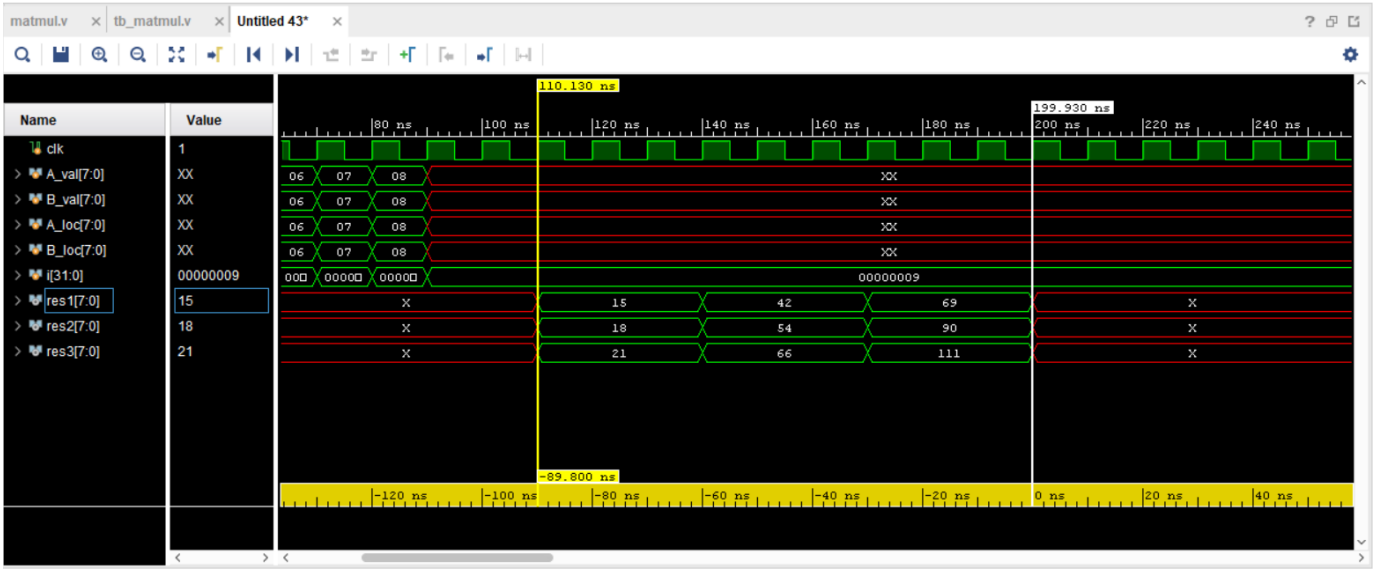


Hence to calculate each column 9 cycles are needed (Since they are pipelined will need only 9 for calculation of the whole matrix)

Consider Another example



Simulation Waveform (Tool: Vivado)



Hence it can be observed the number of clocks required is 9 Cycles
Res1 is the first column of the resultant matrix
Res2 is the second column of the resultant matrix
Res3 is the third column of the resultant matrix

Hardware implemented Waveform (Used ILA and VIO Logic Analyzers)