

$$\begin{array}{r} 91 \\ 91 \end{array} \begin{array}{r} \times \\ \times \end{array} \begin{array}{r} -9 \\ -9 \end{array}$$

Here, we get same result on cross addition.

$$\begin{array}{r} 91 \\ 91 \\ \hline 82 \quad 81 \end{array}$$

Figure 2 Multiplication of 2-bit number.

Thus result of 91×91 will be 8281. This technique is suited for the numbers to be multiplied which are nearer to the base.

B Urdhva - Tiryagbhyam

Urdhva –Tiryagbhyam means “Vertically and crosswise”. It is the general formula applicable decimal number as well as binary numbers and for all cases of multiplication.

It is based on a novel concept through which the generation of all partial products and then concurrent addition of these partial products can be done. Thus parallelism in generation of these partial products and their summation is obtained using Urdhva-Tiryagbhyam. The algorithm can be generalized for n bit number, since the partial products and their sums are calculated simultaneously.

To explain this multiplication, consider the multiplication of two decimal numbers ($12 * 14$). Initially the rightmost digits on the both sides are multiplied and results in least significant digit of product result and if carry is generated. This carry is added in the next step and the process goes on likewise. In each step, least significant bit act as the result digit and all other digits act as carry for the next step. Initially zero is to be taken as carry.

a) Two 2 digit number Multiplication:

Ex.1: Find the product 22×14

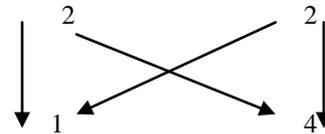
i) The right hand most digit of the multiplicand (22) i.e., 2 is multiplied by the right hand most digit of the multiplier (14), the second number (14) i.e., 4. The product $2 \times 4 = 8$ forms the least significant part of the answer.

ii) Now, diagonally multiply the first digit of the multiplicand (22) i.e., 2 and second digit of the multiplier (14) i.e., 1 (answer $2 \times 1 = 2$); then multiply the second digit of the multiplicand i.e., 2 and first digit of the multiplier i.e., 4 (answer $2 \times 4 = 8$); add these two i.e., $2 + 8 = 10$. It gives the next, i.e., second digit of the answer. Hence second digit of the answer is 0, here carry is generated so add carry (1) to the next step.

iii) Now, multiply the second digit of the multiplicand i.e., 2 and second digit of the multiplier i.e., 1 vertically, i.e., $2 \times 1 = 2$. Add the previous carry. It gives the left hand most part of the answer.

Thus the answer is 308.

Symbolically this can be represented by following process:

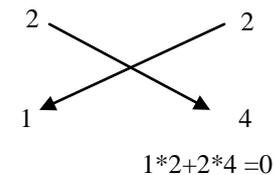


The processes will be from right to left.

Step i)

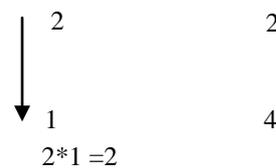


Step ii)



Sum will be 10, so 1 is carry

Step iii)



Now, answer can be written as, 308.

Consider two 4-bit binary numbers $x_3x_2x_1x_0$ and $y_3y_2y_1y_0$. The partial products ($P_7P_6P_5P_4P_3P_2P_1P_0$) generated are given by the following equations:

- i. $P_0 = x_0y_0$
- ii. $P_1 = x_0y_1 + x_1y_0$
- iii. $P_2 = x_0y_2 + x_1y_1 + x_2y_0 + P_1$
- iv. $P_3 = x_0y_3 + x_1y_2 + x_2y_1 + x_3y_0 + P_2$
- v. $P_4 = x_1y_3 + x_2y_2 + x_3y_1 + P_3$
- vi. $P_5 = x_1y_2 + x_2y_1 + P_4$
- vii. $P_6 = x_3y_3 + P_5$
- viii. $P_7 = \text{carry of } P_6$

III. CONCLUSIONS

Urdhva –Tiryagbhyam is only sutra which can be used for both decimal number system as well as binary number system for multiplication with high speed.

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