

# IDP

## Fixed-Point Matrix Multiplication

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Problem statement and Implementation Strategy

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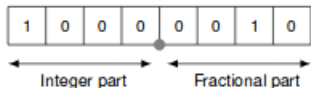
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# Introduction

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# Fixed Point Matrix Multiplication

The main idea of fixed point arithmetic is to interpret bit words as integers coupled with a scale factor:  $\frac{z}{2^n}$



$$\begin{array}{c|c} z & 2^7 + 2^1 = 130 \\ \hline \text{Value in fixed-point} & \frac{130}{2^4} = \frac{2^7 + 2^1}{2^4} = 2^3 + 2^{-3} = 8.125 \end{array}$$

Multiplication: The product of a  $Q_{a,b}$  variable by a  $Q_{c,d}$  yields a  $Q_{a+b,c+d}$  variable.

$$\begin{array}{r} \boxed{1\ 0\ 1\ 0\ 0\ 0\ 1\ 0} \quad 5.0625 \\ \times \boxed{0\ 1\ 0\ 1\ 1\ 0\ 1\ 1} \quad 1.421875 \\ \hline \boxed{0\ 0\ 1\ 1\ 1\ 1\ 0\ 0\ 1\ 1\ 0\ 1\ 0\ 1\ 1\ 0\ 1\ 0} \quad 7.198242187 \end{array}$$

# Fixed Point Matrix Multiplication

Table 1: Fixed-Point Examples

Binary	Hex	Integer	Floating Point Fraction	Fixed-Point Fraction	Actual
0100000000000000	4000	16384	0.50000000	0.50000000	1/2
0010000000000000	2000	8192	0.25000000	0.25000000	1/4
0001000000000000	1000	4096	0.12500000	0.12500000	1/8
0000100000000000	0800	2048	0.06250000	0.06250000	1/16
0000010000000000	0400	1024	0.03125000	0.03125000	1/32
0000001000000000	0200	512	0.01562500	0.01562500	1/64
0000000100000000	0100	256	0.00781250	0.00781250	1/128
0000000010000000	0080	128	0.00390625	0.00390625	1/256
0000000001000000	0040	64	0.00195312	0.00195312	1/512
0000000000100000	0020	32	0.00097656	0.00097656	1/1024
0000000000010000	0010	16	0.00048828	0.00048828	1/2048
0000000000001000	0008	8	0.00024414	0.00024414	1/4096
0000000000000100	0004	4	0.00012207	0.00012207	1/8192
0000000000000010	0002	2	0.00006104	0.00006104	1/16384
0000000000000001	0001	1	0.00003052	0.00003052	1/32768
0010101010101011	2AAB	10923	0.33333000	0.33334351	0.33333
0101101001111111	5A7F	23167	0.70700000	0.70700073	0.707
0000000000001010	000A	10	0.0003141592	0.00030518	0.0003141592
0000000000000011	0003	3	0.000086476908	0.00009155	0.000086476908

# Fixed Point Matrix Multiplication

- It is similar to a normal matrix multiplication, whereas here we use fixed point multiplication between the numbers.
- The input is stored in the BRAM memory block and after the computation output is also stored in BRAM memory block

# Problem Statement

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# Problem Statement

- input matrices will be taken from keypad.
- fixed point numbers must be used to multiply and generate a matrix in Ico board (result of multiplication of two matrices).
- the output will be displayed via Arduino.



# Implementation Strategy

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# Implementation Strategy

- mode of input is keypad which is connected to Arduino.
- Arduino converts floating point input to fixed point output.
- Ico board receives input from Arduino where matrix multiplication is programmed.
- Ico board sends the output after the multiplication process to Arduino.
- The output matrix can be displayed in Arduino-python interface after floating point conversion.

The Project will be implemented for  $(3 \times 3)$  matrix. And 8-bit fixed-point numbers will be used.

**THANK YOU**