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# Error Analysis of Imprecise Multipliers

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***Abstract*—Multiplication is frequently required in digital signal processing and multipliers are one of the primary sources of power consumption in DSP applications. So by using such type of multipliers which consume less power in order to perform its operation, we can minimize the power required for such DSP applications as compared to that application in which traditional multipliers are used. Imprecise multiplier is also that type of multiplier which required less power on the cost of some fluctuations from the original result. In modern VLSI technology, the occurrence of all kinds of errors has become inevitable. So we can use the imprecise multiplier in various DSP applications depending on error tolerance capacity of that application. So it becomes necessary to determine the error probability of that multiplier in order to use that in any resents application. This paper presents the error analysis of imprecise multipliers.**

*Index Terms*—**DSP, Multiplier, VLSI.**

## I. INTRODUCTION

In most of DSP applications, the critical operations usually involve many multiplications and /or accumulations .In order to perform the proper operation, the multipliers requires more hardware resources and processing time than addition and subtraction. So the multipliers are the primary sources of power consumption in DSP application [13]. his power consumption can be reduced by using the imprecise multipliers. In modern technology it is more desired to reduce the size of any design in order to make it more compact. Since the imprecise multiplier has less compact size so they can be used in error tolerant applications to make them more compact.

## II. PRINCIPLE OF IMPRECISE MULTIPLIER

The design of imprecise multiplier is based to introduce error into the multiplier by manipulating its logic function, using the 2x2 multiplier as a building block. The basic concept behind the design of imprecise multiplier is that, in imprecise multiplier we get (111) as a result of multiplication of 3x3 instead of (1001). So there is a error of 2(9-7) in just one case out of 16 case. So there is a error probability of 1/16.The accurate multiplier is shown in fig.1 (a)[1] and the imprecise multiplier in shown in fig1(b)[1]..

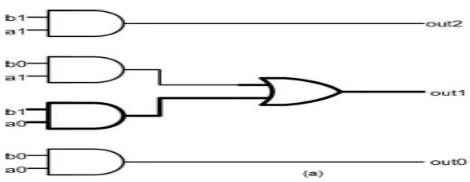

**Fig.1. (a).The 2x2 multipliers paths highlighted**

The inaccurate version has close to half the area of the accurate Fig. 1(b) version; a shorter and faster critical path and fewer wires. Since the inaccurate version of the 2x2 multiplier has smaller switching capacitance than its accurate counterpart, it offers the potential for significant dynamic power reduction for the same frequency of operation.

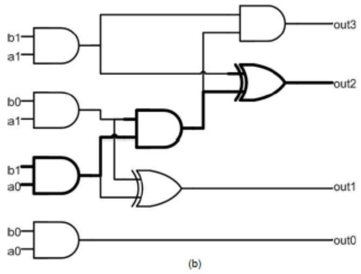

**Fig 1(b).The imprecise 2x2 multipliers, with the critical paths highlighted**

Larger multipliers can be designed by using inaccurate 2x2 block to produce partial products and then adding the shifted partial products. Fig.2 [1], shows an example of a single 4x4multiplier built out of four 2x2 blocks, where AH, XH and AL, XL are the upper and lower two bits of inputs A, X respectively. Hence larger multiplier blocks can be built out of the 2x2 building block, and still perform better in terms of power and area as compared to accurate architectures.

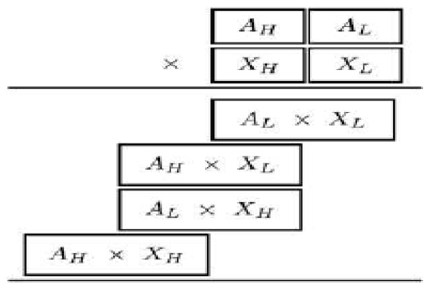

**Fig 2. Building larger multipliers from smaller blocks**

## III. ERROR ANALYSIS

The imprecise multipliers have a fixed mean of error and error probability. Since 2X2 multiplier is used as basic building blocks in order to design the higher bits multiplier. So we can design the higher bits multiplier in different configuration depending on the error tolerance capacity of the application in which that multiplier is to be used. In this configuration it is possible to replace these individual components with accurate versions to reduce the error rate and mean error. Such a replacement results in smaller power savings, but provides a means to

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achieve different points on the error vs. power savings trade-off curve. The resulting power vs. accuracy curve for our inaccurate multiplier may be varied according to the requirement of the applications. For example if we use the multiplier for image processing then we can use more imprecise multiplier since naked human eyes can not differentiates in the image quality beyond a limit. So the designs of imprecise multiplier depend on the error tolerance capacity of the application. The error probability of imprecise multiplier can be calculated in two steps.

### A. Function for Imprecise Multiplier

In order to analyze the errors of imprecise multipliers first of all we have to write the function for imprecise multiplier which is recalled in the MATLAB program for error calculation.

#### i. Function for 2x2 Imprecise Multiplier

The function for 2X2 imprecise multiplier is given as:

```
function y= mult2by2approx(a,b);
if((a == 3) && (b == 3)
y= 7;
else
y= a*b;
end;
```

#### ii. Function for 4x4(3A1I) Imprecise Multiplier

The function for 4X4 imprecise multiplier (in which 3 accurate multipliers and 1 imprecise multipliers is used) is given as:

```
function z= mult4by4oneblockapprox(x,y);
x0= rem(x,4);
tmp= x- x0;
x1= tmp/4;
y0= rem(y,4);
tmp= y- y0;
y1= tmp/4;
r1= mult2by2approx(x0,y0);
r2= x1*y0;
r3= x0*y1;
r4 = x1*y1;
z= r4*16 + (r3+r2)*4 + r1;
```

#### iii . Function for 4x4(1A3I) Imprecise Multiplier

The function for 4X4 imprecise multiplier (in which 1 accurate multipliers and 3 imprecise multipliers is used) is given as:

```
Function
z= mult4by4threeblockapprox(x,y);
x0= rem(x,4);
tmp= x- x0;
x1= tmp/4;
 y0= rem(y,4);
tmp= y- y0;
y1= tmp/4;
r1= mult2by2approx(x0,y0);
r2= mult2by2approx(x1,y0);
r3= mult2by2approx(x0,y1);
r4= x1*y1;
z= r4*16 + (r3+r2)*4 + r1;
```

#### iv. Function for 4x4(4I) Imprecise Multiplier

The function for 4X4 imprecise multiplier (in which 1 accurate multipliers and 3 imprecise multipliers is used) is given as:

```
function z= mult4by4fullapprox(x,y);
x0= rem(x,4);
tmp= x- x0;
x1= tmp/4;
 y0= rem(y,4);
tmp= y- y0;
y1= tmp/4;
r1= mult2by2approx(x0,y0);
r2= mult2by2approx(x1,y0);
r3= mult2by2approx(x0,y1);
r4= mult2by2approx(x1,y1);
z= r4*16 + (r3+r2)*4 + r1;
```

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## IV. RESULTS

After comparison the various configurations of multipliers on the bases of different parameters (such as mean error, normal error etc.) in the tabular form is following.

| Multiplier | Mean Error | Norm Error | Occurrence |
|---|---|---|---|
| 2-bit Accurate | 0 | 0 | 0 |
| 2-bit Imprecise | 0.124 | 0.013 | 0.062 |
| 4-bit Accurate | 0 | 0 | 0 |
| 4-bit Imprecise(1I3A) | 0.125 | 0.0031 | 0.019 |
| 4-bitImprecise(3I1A) | 1.11 | 0.014 | 0.115 |
| 4-bit Imprecise(4I) | 3.12 | 0.026 | 0.176 |

**Table1: Comparison in mean error normal error and occurrence.**

Results shows that the full analysis of error which are concerned in case of imprecise multiplier. Since the occurrence of error is very less which can be tolerated easily in many application. As we can see from the table the error occurrence is increased as the no. of imprecise multipliers is increased. Since the imprecise multipliers are much compact in size and the delay of these circuits is also much less.

## V. CONCLUSION

Multiplication is one of the basic functions beside addition used in almost digital signal processing cores. It requires more hardware resources and processing time than addition and subtraction. There are many applications which can tolerate small amount of error e.g. multimedia applications which produce results (image/video) for human consumption. In these applications imprecise designs may be used to reduce the size and power consumption. This thesis explore the imprecise multiplier and shows the gain achieved (reduction in size, power consumption and delay) at the cost of minor increase in error. this technique can be further used in order to improve the performance of portable devices since the power required for this type of multipliers is less. So the by using this we can reduce the battery size for that application and can make the portable device more compact.

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