



iJRASET

International Journal For Research in
Applied Science and Engineering Technology



INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 9 Issue: III Month of publication: March 2021

DOI: <https://doi.org/10.22214/ijraset.2021.33372>

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Design of a 16-Bit Posit Multiplier with Power Efficiency

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Abstract: Considering the many number of arithmetic functions or operations existing till now, we deem multiplication to be one of the most utilized function. They are implemented in various fields. Most notable applications are signal processing, graphics and scientific computation. Posit number system is widely used nowadays in replacement for IEEE number system. In this paper, we propose the architecture of a 16-bit modified posit multiplier, which results in less power consumption. In the posit multiplier, our work relates to the mantissa multiplier. The multiplier used for mantissa is structured mainly for providing maximum bit-width that is possible, where the entire multiplier can be partitioned to produce smaller multipliers. Only the necessary partitioned multipliers will be used during the time of execution. Thus resulting in less power consumption.

Keywords: Posit multiplier, Mantissa multiplier, Less power consuming circuit, Modified booth encoding, 16-bit multiplier.

I. INTRODUCTION

Posits, a new data-type modeled to build as an alternative for IEEE floating point number. Posit number do not demand any operand to be of varying size (variables) because if they find any answer to be wrong, they do the rounding process. This behavior is very much unlike the universal numbers or also known as unum. The posit system yields many benefits, which may include their dynamic range being large, use of a simple hardware execution system, handling of exceptional cases are comparatively better, being greater in terms of accuracy. Posits do not take the values of infinity and zero. As enunciated before, posit processing system occupies less equipment compared to IEEE floats processing machine. Additionally, they have a irregular or inconsistent distribution of data that settles the need in certain applications, for example it may be useful in deep learning. The 8-bit or 16-bit posits are generally utilized in deep learning applications. 32-Bit posits arithmetic may be utilized scientifically computing fields. The generalized pattern for the posit data-type or number system is shown in Fig. 1. Posit (nb , es) is the representation of posits where nb means total or absolute bit width and es means the bit width foe exponent. It constitutes 4 parts: 1.sign→s 2.regime→rg 3.exponent→exp 4.mantissa→frac. The component width of the bit is variable. The regime values are always varying. The rest of the positions for the bits shall be taken by mantissa ans also the exponent. This happens only when the regime does not reserve all the positions. A numeral illustrated in the format for posits arithmetic:

$$value = (-1)^s \times useedrg \times 2^{exp} \times (1 + frac) \quad (1)$$

where $useed = 2^{2es}$.

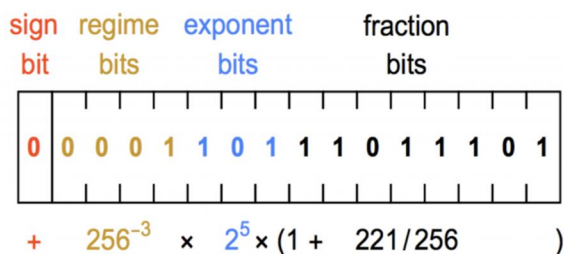


Fig. 1 Posit number system

We have dynamic ranging bit width here as shown in Fig. 1, exemption being the sign bit sized 1. The regime as well as the sign bit should always be present in the general structure. Exponent and mantissa sections occur if there any leftover positions for the bits. As such the fraction part which includes the implicit bit also has a bit-width ranging from 1 to $nb - es$ value. Every time we do any operations, the value of mantissa need not be to its full extent always. Using a maximum bit multiplier all the times results in unwanted consumption of power.

We establish the successful implementation of a 16 – bit posit multiplier, where the mantissa (fraction) multiplier is split into several small ones and use them when required. Thus we efficiently design a low power consuming posit multiplier and reduce increasing power consumption. This architecture can also be used in various multipliers other than posit multipliers to improve power efficiency of the corresponding component or device. The upcoming sections are as follows: *Segment II* describes the existing multiplier method. *Segment III* briefs the proposed method. *Segment IV* presents the software generated result of our multiplier. Lastly *Segment V* concludes the paper.

II. EXISTING METHOD

Currently the working method of posit multiplier uses the modified booth's algorithm technique. This method is also known as bit-pair algorithm or radix-4 algorithm. There is a possibility to decrement the partial products number. Here we do not shift and add for all the columns of the multiplier and later doing multiplication with 0 or 1. But what we do here is to multiply every 2^{nd} column with 0 or ± 1 or ± 2 . Both the methods yield similar results. Radix-4 booth encoder compares 3 bits at a time which is also known as the overlapping method. By adding a zero the the left end of the number, we start pairing them into a batch of 3 numbers together shown in Fig. 2.



Fig. 2 3-bit pairing for Booth recoding

Operating procedure for Radix-4 booth encoder is as shown in the Fig. 3. The results achieved from multiplying the different multiplier states with 0, ± 1 and ± 2 are described.

Multiplier Bits Block			Recoded 1-bit pair		2 bit booth	
i+1	i	i-1	i+1	i	Multiplier Value	Partial Product
0	0	0	0	0	0	$M \times 0$
0	0	1	0	1	1	$M \times 1$
0	1	0	1	-1	1	$M \times 1$
0	1	0	1	0	2	$M \times 2$
1	0	0	-1	0	-2	$M \times -2$
1	0	1	-1	1	-1	$M \times -1$
1	1	0	0	-1	-1	$M \times -1$
1	1	0	0	0	0	$M \times 0$

Fig. 3 Radix-4 method booth recoding

Radix-4 Booth encoding procedure is as follows: (1) Make sure n is even, so if necessary create an extension using the sign bit. (2) Adjoin zero value to the LSB in our multiplier. (3) Depending upon each and every value, we form partial products as $-y$, $+y$, $-2y$, $+2y$ or 0. Two's complement procedure is done to deal with negative values. After shifting the multiplier y bit one by one, multiplication process is thus proceeded. We obtain partial produced reduced by twice its size which is a main advantage. This reduction facilitates the decreased delay in propagation while the circuit is operating. The main disadvantage of the circuit mentionable must be the difficulty in the construction of the circuit hardware.

Fig. 5 Reduced partial products bit in proposed system

For completing the design of our multiplier, we need a control signal. We divide the 16-bit digit input into four parts as already mentioned above. To generate Control Signal for both the inputs, one has to identify the position in where the binary digit '1' makes its appearance. After discovering the position of 1, comparison of the divided subgroups and our input digit is performed. According to that grouping, we generate the control signal for both inputs. This in turn implies the selection of smaller multiplier which we need to use for the process. All in all we sum-up the use of control signal to select the smaller multiplier we have partitioned for the operation.

The entire simulation and result obtaining using test vectors are done with the help of ModelSim software. We have used the ModelSim 6.3f version for its ease in finding errors.

Fig. 6 Output sample 1 after simulation

Fig. 7 Output sample 2 after simulation

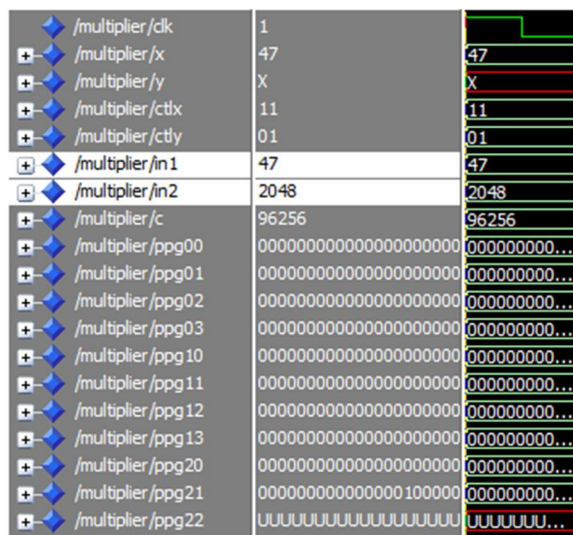


Fig. 8 Output sample 3 after simulation

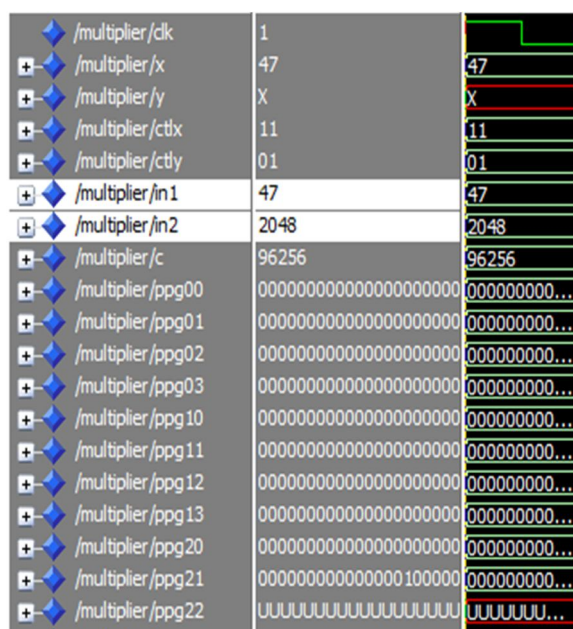


Fig. 9 Output sample 4 after simulation

In the above presented Fig.6 to Fig. 9, we have shown the simulation results after inputting test vectors. For the proposed design of Posit(16,1), we have achieved about a 20% cutback in power. The residue is left out in order to eliminate the toggling of the signal. We set the unwanted segments to 0, thus avoiding toggling in the last steps of rounding and adding. Such factors contribute to the lessened power consuming in our design structure.

V. CONCLUSION

The idea proposed in the paper is a 16-bit Posit multiplier architecture with power efficiency. Intrigued by the idea of reconstructing the multiplier unit for mantissa into smaller parts, because of the whole mantissa unit is not used entirely all the time, we have built the hardware. To limit the power consumption, we use only the necessary potion of the multiplier. The proposed method is evaluated to find that we can achieve about 16% reduction in power consumption. Our method is evaluated for 16-bit multiplier, whereas we can extend the work for 8-bit and 32-bit posit multipliers using the same technique. For futuristic purposes, more power reduction techniques for multiplier architecture can be developed. The work need not be necessarily limited to multipliers alone. Future works can be deployed also for Posits Adder or Posits Multiply Accumulate functions.



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