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Ultra Low Power Compressor Based Multiplier Circuits for Robots

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Abstract. As today's modern autonomous robots consist of many sensors ,multiple processors and artificial intelligence software. For this, it draws data from the input sensor and process them into meaningful information with the help of an on board microcontroller unit ,MCU otherwise known as the processor. It is also responsible for taking decisions based on the information provided by the sensors and therefore, tells the output devices how to function and do a task. Processors are the main thinking and evaluating part of any of the robot. Main purpose of the processors and the CPU is performing of functions out of which most of them are performed using multipliers in the processor. Compressor are mainly used for designing different type of power efficient multipliers. In this work ,a 3:2 And 4:2 compressor are designed using XOR-XNOR circuit. This innovative design structure of 3:2 and 4:2 compressor helps in power consumption and delays as compared to todays existing designs. The simulated results shows improvement in the performance parameters. It indicates decrement in the power consumption by13.46%for 3:2 compressor and 25.29% for 4:2 compressor at 2.5v obtained from the comparison with the existingstate of art.

Keywords. Processor, Multiplier, Compressor, XOR-XNOR circuit

1. Introduction

Today the whole globe is digitally connected using high proficiency technologies which are used today in products like mobile, computers, smart phones[1]. Digitization has almost taken all the portion of engineering mainly mechanical and automation along with the other engineering disciplines. Most of the automation control needs processors which have to be faster, portable and power efficient. As CPU is the heart of every embedded system and CPU is the main dealing portion in the robotics and automation in the field of ALU(arithmetic and logical unit). This functionality fully depends upon multipliers and are performed by compressor based multipliers[1].

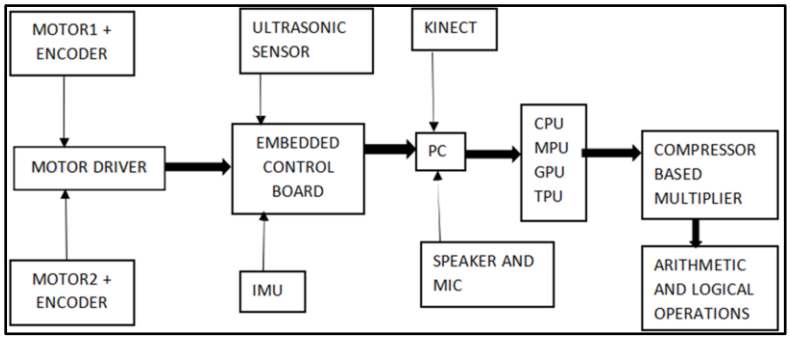

Fig 1: Block diagram of robot

In multipliers mainly compressor is the which is mostly used in CPU, automation systems , robots and various VLSI systems and circuits. They are mainly used for performing product solution which is partially present during multiplication processes. The work consist of implementation of 3:2 and 4:2 compressor using XOR-XNOR circuit. The main focus is to obtain reduction in power and delay using design circuit[2]. These compressor based multiplier are provided embedded in microcontroller and microprocessor which provide high performance and less power consumed outputs. Mainly the appropriate processor to be used depends on the goal the device is required to meet. Following types of processor are used in robotics like MCU,CPU,GPU,TPU[2].

MCU(Microcontroller unit): They are effectively cheap and works well with sensors. They have the ability to control hardware .They are economically and easily adaptable for the robotics. It needs certain development and programming conditions.

CPU(central processing unit):It permits us to run software on the operating system as linux and is not difficult to program.

GPU(Graphics processing unit):It is mainly designed for the photos and videos processors. It is used for 3D graphics, videos, streaming processing etc.

TPU(Tensor processing unit): Largely designed for tensor flow, which is an open source learning framework. It is specially designed to work with neutral networks.

2. Background

As we know that there are many of the devices which are digitally processing and portable devices in automation. The main processing element for this is compressor. There are many processors and criteria for designing compressors which includes compressor using XOR gates, compressor using half adder and compressor using full adder in many of the papers[2].

2.1 XNOR-XOR Circuit

The XNOR-XOR circuit is depends on cross coupling structures and CPL . This circuit is implemented on the basis of two division. The first division consist of two PMOS and three NMOS transistors at the output of XOR. The second division consist of two

NMOS and three PMOS in the output of XNOR[3]. If considering about XOR pmos1 and pmos2 have been connected in parallel as shown in figure 1 and nmos4 and nnmos5 are provided with a full swing output and nmos3 here plays the role of feedback transistor. If considering about XNOR nmos1 and nmos2 have been connected in parallel as shown in figure 1 and pmos4 and pmos5 are provided with a full swing output and pmos3 plays the role of feedback transistor. There is an existence of only paths that can provide both full swing and partial results at the output points[3]

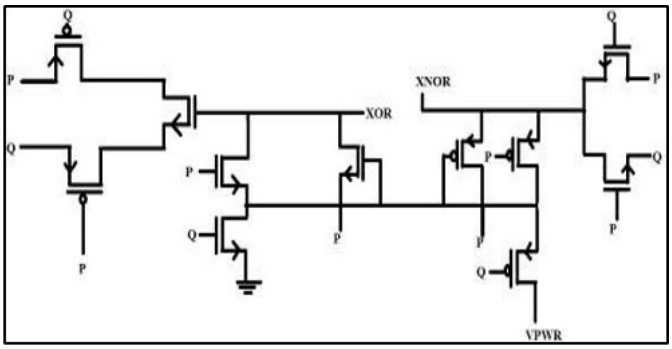

Fig 2: Schematics of XNOR-XOR[3]

2.2 The 3:2 Compressor

There are many of the existing designs of 3:2 compressor out of which one of the design is compressor using XORgate.

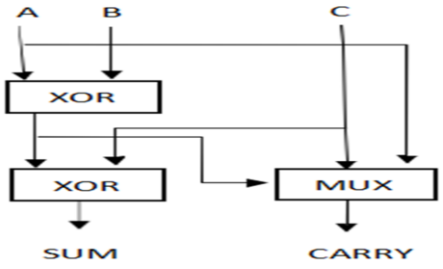

Fig 3: The 3:2 compressor using XOR gate[4]

A	B	C	CARRY	SUM
0	0	0	0	0
0	0	1	0	0
0	1	0	0	0
0	1	1	1	1
1	0	0	0	0
1	0	1	1	1
1	1	0	1	1

Fig 4: Truth diagram of 3:2[4]

Equations:

$$SUM = A \oplus B \oplus C$$

$$CARRY = (A \oplus B) * C + (A \oplus B)' * C$$

It is similar to full adder and similarly works as full adder works. They have a large application in robotic and automation as being the part of processor in the form of multiplier for the image processing[2].

2.3 The 4:2 Compressor

Some of the existing circuits of 4:2 compressor are given using XOR circuit.

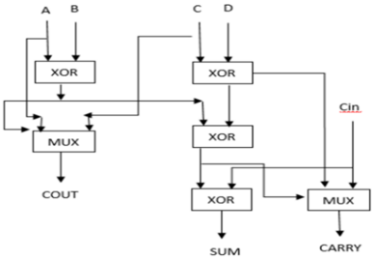

Fig 5: The 4:2 compressor using XOR gate[4]

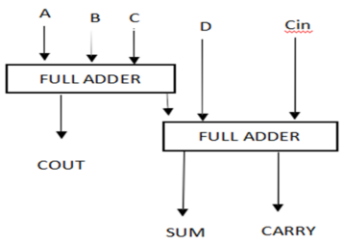

Fig 6: The 4:2 compressor using full adder[4]

Equation:

SUM= A ⊕ B⊕ C⊕ D⊕ Cin CARRY= (A⊕B) * C+ (A⊕B)' * A
COUT= (A⊕B⊕C⊕D) * Cin+ (A⊕B⊕C⊕D)' * D

The above two circuit diagram of 4:2 compressor are presented in the existing paper and have a vast application in automation and manufacturing of multipliers[2,3].

3. Proposed Design

As we know that there are many of the devices which are digitally processing and portable devices in automation.The main processing element for this is compressor. The work consist of designing 3:2 and 4:2 compressor using XNOR-XOR circuit. In this paper XNOR-XOR circuit is used to design compressor and the power and delays are compared with the existing results of various papers. In this paper analysis is done for power consumption and delay[3].

3.1 The 3:2 Compressor

It shows most the similarity with full adder. It consists of three inputs and two outputs as shown in figure number2.Let the inputs be P,Q and R and outputs obtained are S and C bits.
S=sum C=carry

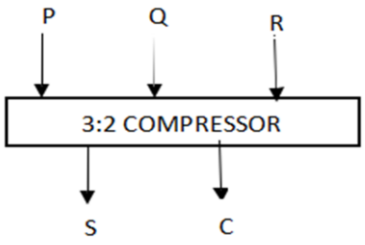

Fig 7: Block diagram of 3:2 compressor[4]

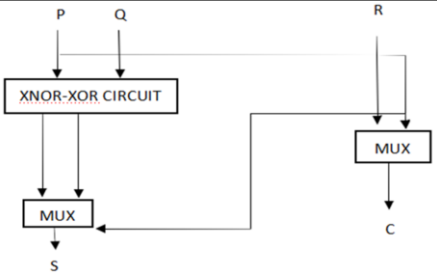

Fig 8 : Circuit diagram of 3:2 compressor

In this circuit instead of XOR gate mentioned in section 2.1 ten transistor XNOR-XOR circuit is used.

3.2 *The 4:2 Compressor*

It contains mainly three outputs and five inputs as shown in figure 4[5]. Let us consider the inputs to be P,Q,R,Sand Cin and output obtained are Sm,Cry and cout where Sm=sum Cry=carry

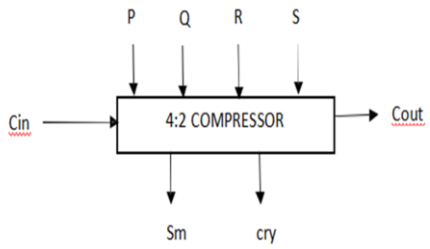

Fig 9: Block diagram of 4:2 compressor[4]

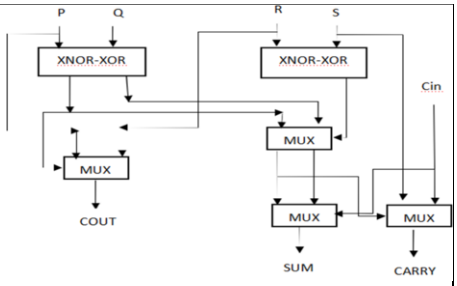

Fig 10: Circuit diagram of 4:2 compressor

3.3 Compressor Based Multiplier

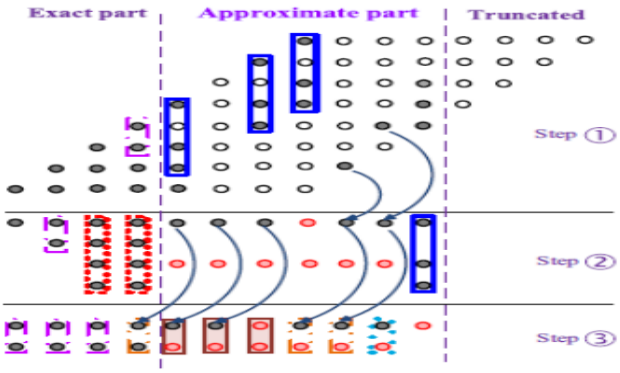

Fig 11:Multiplier[2]

This multiplier can be designed using the proposed model of the compressor. The provided circuit used for manufacturing the multiplier as shown in figure 11 focuses on power consumption and less delays in its usuage. After being the part of the processors in the robots it would play a vital role in the image processing and arithmeticand logical operations in the robotics and can also have a wide usuage in automation[2].

3.4. Waveform of 3:2 Compressor

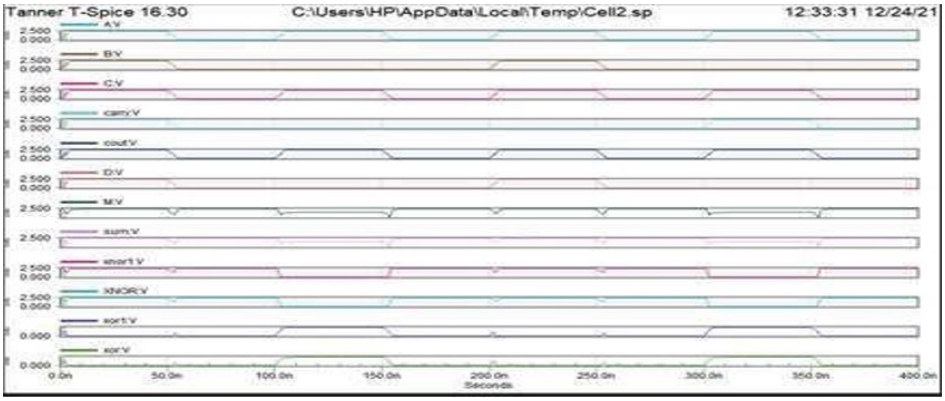

Fig 12: Waveform of 3:2 Compressor

The figure 12 represents the waveform of 3:2 compressor using 10 transistor XNOR-XOR circuit. In the waveform A and B represents the input signal provided to the XNOR-XOR circuit. XNOR and XOR represented in the waveform are the outputs of XNOR-XOR circuit. SUM and CARRY are the outputs obtained from the simulated circuits.

3.5 Waveform of 4:2 Compressor

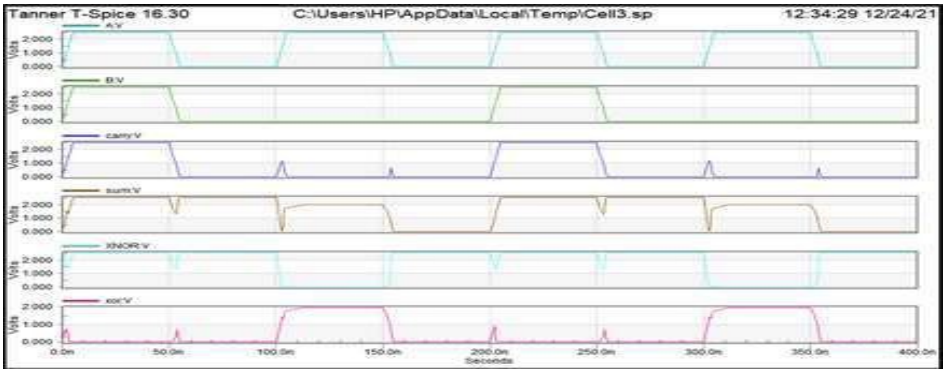

Fig 13: Waveform of 4:2 Compressor

The figure 13 represents the waveform of 4:2 compressor using 10 transistor XNOR-XOR circuit. In this circuit mainly two XOR-XNOR circuits are used. The waveform represents the A and B as the input of 1st circuit and Cand D as the input of 2nd circuit. xor and xnor are the outputs of 1st circuit and xor1 and xnor1 are the outputs of 2nd circuit. When these outputs are passed on to multiplexer sum, carry and cout are obtained as the final output as represented by the waveforms.

4. RESULTS AND DISCUSSION

4.1 Obeservation of 3:2 compressor and 4:2 compressor

S.NO	PARAMETER	3:2 COMPRESSOR	4:2 COMPRESSOR
1.	Average Power Consumption(uW)	39.59	73.59
2.	Delay(ns)	1.45	1.89
3.	Rise time(ns)	4.0787	4.0227
4.	Fall time(ns)	51.775	53.778

The above table shows the parameters being analyzed from the proposed the design of the compressors. These parameters are being compared with the existing design parameter. The main purpose of designing this compressor is to make efficient use of this circuit for designing less consuming power multiplier for the processors used in robots.

4.2 Comparison with the existing circuit

CIRCUIT	COMPARISON	POWER CONSUMPTION(uW)	DELAY(ns)
3:2 COMPRESSOR(AT 2.5V)	[8]	49.75	1.61
	THIS WORK	39.59	1.45
4:2 COMPRESSOR(AT 2.5V)	[8]	98.91	2.36
	THIS WORK	73.59	1.89
4:2 COMPRESSOR(AT 2V)	[10]	17.255	2.69
	THIS WORK	15.125	2.21

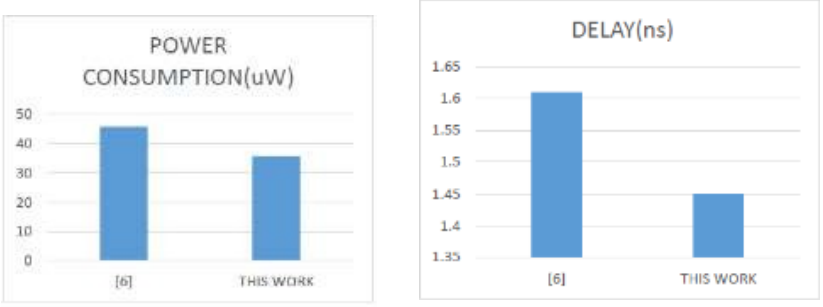

Fig 14: Graphical comparison of power consumption and delay for 3:2 compressor at 2.5v

The figure 14 represents the comparison between this work and the existing state of art[6].The graph of power consumption and delay represents that there is decrease in power consumption and delay at 2.5v in the proposed design as compared to the

existing work. The reduction obtained in power consumption and delay is 13.46% and 9.9%[6].

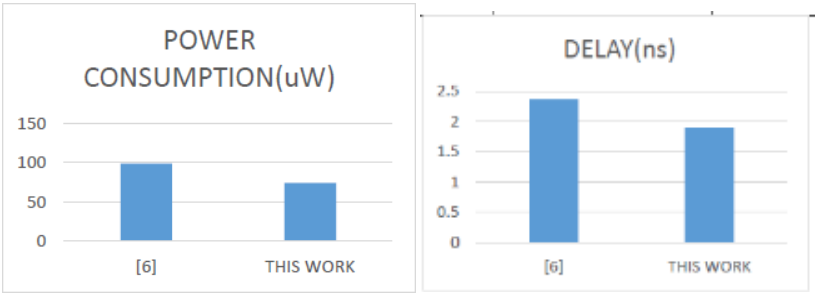

Fig 15: Graphical comparison of power consumption and delay for 4:2 compressor at 2.5v

The figure 15 represents the comparison between this work and the existing state of art[6].The graph of power consumption and delay represents that there is decrease in power consumption and delay at 2.5v in the proposed design as compared to the existing work. The reduction obtained in power consumption and delay is 25.29% and 19.9%[6].

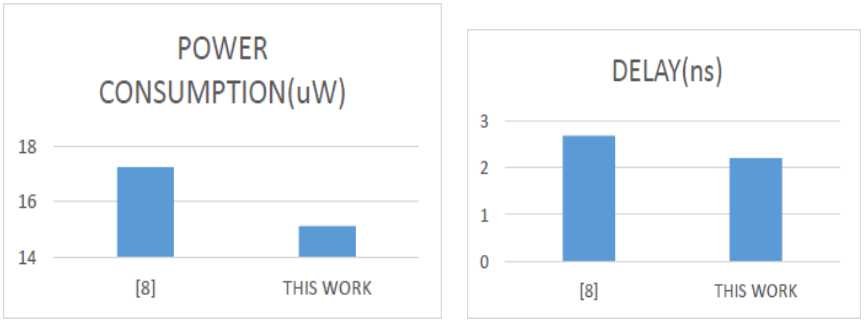

Fig 16: Graphical comparison of power consumption and delay for 4:2 compressor at 2v

The figure 16 represents the comparison between this work and the existing state of art[8].The graph of power consumption and delay represents that there is decrease in power consumption and delay at 2v in the proposed design as compared to the existing work. The reduction obtained in power consumption and delay is 12.344% and 18.08%[8].

5. CONCLUSION

The architecture of 3:2 compressor and 4:2 compressor are analyzed using the EDA tool. In this paper 10 transistorXNOR-XOR circuit has been taken for design the compressor. All the schematics and waveforms have been presented in the paper using the EDA tool. The presented paper is compared with the existing results of various papers. The

main motive of this comparison is to bring this design in use for the manufacturing of the multipliersused in the processors as the part of robotics[1].The main concentration is on providing a design which would be a part of robots processors which works efficiently with less power consumption. According to the analysis the circuit of 3:2 compressor provided in thispaper have reduced the power consumption up to 13.46% and the circuit of 4:2 compressor provided in this paperhas reduced the power up to 25.29% for 2.5v power voltage . Therefore, these results are obtained from the comparison with the existing state of art[1,6,8].It has a great future scope in robotics and automation. Using these designs of compressors, multipliers can be designed for power consumption derivative purpose and had a usage in image processing which is a big requirement in robotics.

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