

# DESIGN AND ANALYSIS OF A 4-BIT LOW POWER UNIVERSAL BARREL-SHIFTER USING 2×1 MUX IN 16NM FINFET TECHNOLOGY

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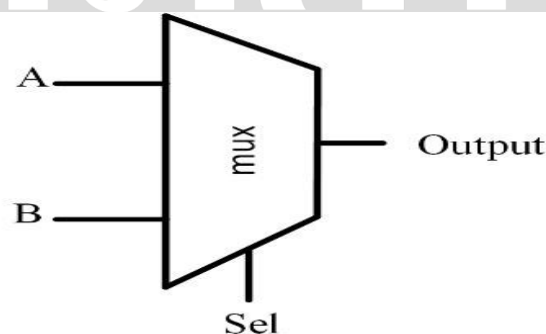
**Abstract-**This project examines the implementation of the barrel shifter using 2×1 multiplexer in FINFET technology. The 2×1 mux is further constructed into the 4×1 mux and used in the implementation of the barrel shifter. The functionality is comparable, yet there is difference in terms of power consumption. The techniques that have been studied are PT(pass transistors). Because the maximum and minimum power consumption are controlled, the PT-based technique has holistic power. The multiplexers are constructed at the 45nm CMOS technology node and simulated . CMOS transistors lost their credibility aft downscaling above 22nm, which generates undesired short-channel effects, particularly "off-state" leakage current, which raises device's optimum power need. Fin-type FINFETs are a promising nanoscale alternative for bulk CMOS. For the implementation of the barrel shifter, the CMOS is replaced by high performance FINFETs in this project. This paper discuss about the implementation of the barrel shifter using fin type transistors (FINFET) and is compared with the CMOS technology.

**Keywords-**CMOS, FINFETS, Multiplexer, Barrel Shifters

## I. INTRODUCTION

For efficiency, most integrated circuits are now constructed in CMOS. However, CMOS lost credibility when it scaled above 22nm. This downscaling produces an undesired short-channel impact, particularly "off state" leakage current, which raises the device's optimum power requirement. Because of that the short-channel effect, numerous alternative devices have been investigated, with FINFETS proving to be more efficient than CMOS. 2×1 Mux is a fundamental unit of "switch logic." Switch logic circuits, as opposed to logic gates, work on the basis of a combination of switches.

Multiplexers are found in programmable logic devices, telecommunications, CPUs, and graphics cards. Data selector is another term for multiplexer. A multiplexer is a mixed circuit that selects and passes binary data from one or more input lines to a single output line in a controlled manner. Two inputs, One output and one input selection are provided by the 2×1 multiplexer circuit. A set of selection lines, as seen in fig , regulate the selection of a specific input line. The selection line determines which bit of the input is transferred to the output. This FINFET technology provides improved scalability, allowing for more effective suppression of "off-state" leakage current while increasing driving current. These transistors provide better electrical control over the channel.



**Fig 1:** symbol of 2×1 Multiplexer

Following that, a universal barrel shifter is designed utilizing a performance 2×1 multiplexer.

The remainder of this work is structured as follows: Section I contains briefs on FINFETs. Section II goes through the main application of the barrel shifter. Section III describes the PT-based MUX using FINFET. Design of CMOS 4×4 crossbar barrel shifter and Universal 4-Bit PT MUX based barrel shifter employing FINFET is covered in Section IV. Section V discusses the

outcomes of analysis and simulation. The simulation and analysis are done using 45nm CMOS and 16nm FINFET technologies in the cadence tool. Section VI comes to a conclusion . Section VII discusses the future scope.

## SECTION I

### FIN-FIELD-EFFECT TRANSISTORS (FINFET)

Because of its potential for use in the construction of CMOS integrated circuits, FINFET devices are being thoroughly researched. Determining MOSFET size has a significant impact on electrostatic characteristics. The indiscriminate fluctuations of the characteristics cause a divergence effect, which is essential from the standpoint of design and is linked to "volume inversion." The FINFET is distinguished by the fact that the conducting channel is surrounded by a thin silicon "fin" that serves as the device's body. The effective channel length of the devices is determined by the thickness of the fin (measured from source to drain). Researchers at the University of California, Berkeley invented the term FINFET to characterize a non-planar, double-gate transistor built on an SOI substrate.

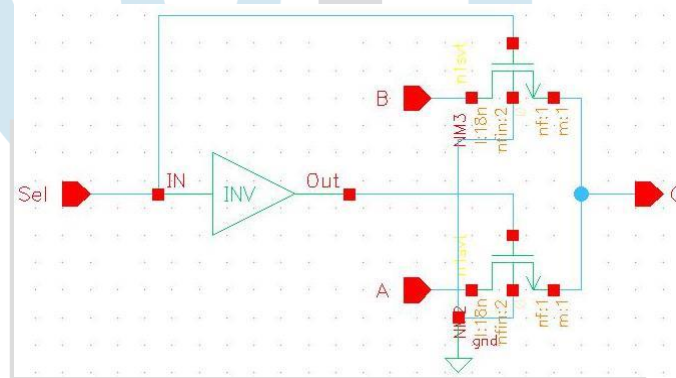
## II. BARREL SHIFTER

In a single clock cycle, a barrel shifter circuit can shift or rotate a data word by a predefined number of bits. It can be implemented as a series of multiplexers, with the output of one mux coupled to the input of the next mux in a manner determined by the shift distance. Consider a four-bit barrel shifter with inputs A, B, C, and D. The shifter can reverse the order of the bits ABCD to produce DABC, CDAB, or BCDA. Because no bits are lost in this scenario. It can shift all outputs to the right up to three positions, resulting in cyclic combinations of A, B, C, and D. The barrel shifter is a popular application.

### THE PT BASED MUX USING FINFET

A PT (Pass Transistor)-based mux circuit diagram is presented below. It has two NMOS and one inverter to reverse the select signal. Many circuits can be designed using a less number of transistors. The input signal is given to the NMOS source, while the select signal and its invert are connected to the gates. The number of transistors has been lowered by utilizing this device.

The advantages of PT-based MUXs are low interconnection effects, low power consumption, and quick operation.



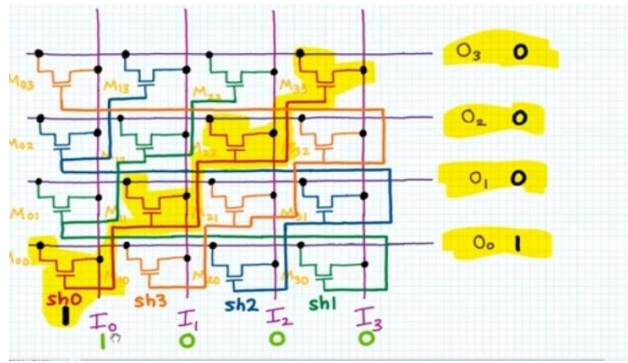
**Fig 3:** PT based multiplexer using FINFET

The source is given to the inputs A and B. The NMOS gate is connected with the inversion of the select signal. It displays the waveform of the output. When Sel=1, input B reaches the output. When Sel=0, the output is the same as the input signal A. Despite the fact that PT only uses two MOS to pass the input signal in a PT-based MUX, they are both NMOS. When Sel is set to zero, input A is routed to the output, resulting in NMOS leakage. If Sel output is directly connected to the input B and leakage occurs at the NMOS where input A is connected.

### DESIGN OF CMOS 4×4 CROSS BAR BARREL SHIFTER AND THE UNIVERSAL 4-BIT PT MUX BASED BARREL SHIFTER USING FINFET

#### A. 4X4 Crossbar Barrel Shifter

Consider the following direct MOS switch implementation of a 4×4 crossbar switch. The configuration is quite general and may easily be expanded to handle n-bit inputs/outputs. In fact, this configuration is excessive in that any input line can be connected to any or all output lines--if all switches are closed, all inputs are connected to all outputs in one spectacular short circuit. Furthermore, to drive the crossbar switch, 16 control signals (m00)-m15, one for each transistor switch, must be given, which is highly undesired.

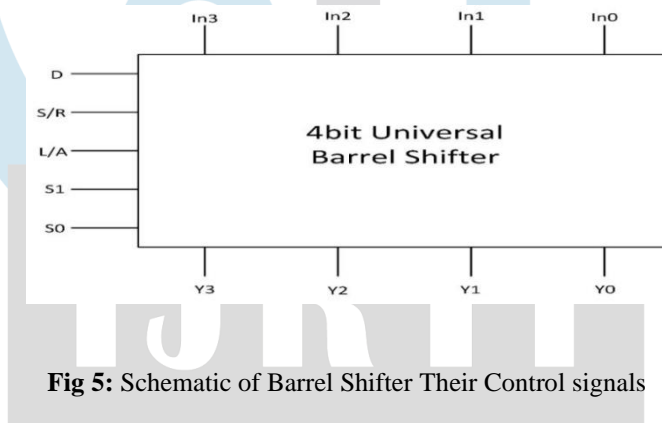


**Fig 4:** 4x4 CrossBar Barrel Shifter Using CMOS

An adaptation of this arrangement recognizes that the switch gates can be coupled together in groups of four in this case, as well as from four different groups corresponding to shifts of zero, one, two, and three bits. To confirm the desired strategy, the design can easily be modified so that the in lines also go horizontally. The resulting configuration is known as a barrel shifter. The gate inputs of the inter bus switches are connected in a staircase fashion in groups of four, and there are now four shift controls inputs that must be mutually exclusive in the active state. If necessary, CMOS transmission gates can be utilised in place of basic pass transistor switches.

**B. Universal 4-Bit PT MUX Based Barrel Shifter Using FINFET**

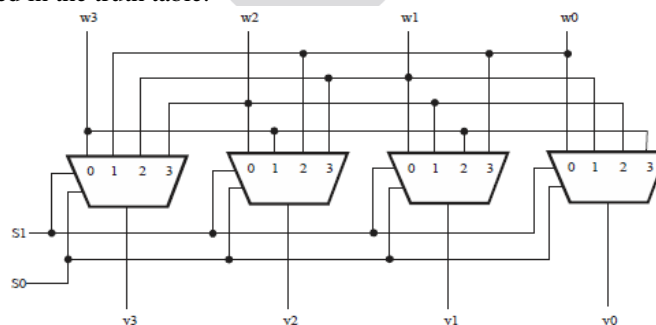
Barrel shifter is a digital circuit that can shift data by a certain amount of bits. The universal barrel shifter is widely utilized in the hardware implementation of floating-point arithmetic. To add or subtract a floating-point number, the significant of the two integers must be the same, and the value of Change the exponent until it equals the greater amount. This is performed by subtracting the exponent number and shifting the smaller number by difference, which is completed in a single cycle by the barrel shifter. whereas transferring the data with a basic shifter would require a greater number of cycles.



**Fig 5:** Schematic of Barrel Shifter Their Control signals

The standard size of the component design is determined by usage and requirements. The barrel shifter may do all the rotate and shift operations. In this section, a 4bit barrel shifter is developed utilizing a PT-based multiplexer, as previously explained. The barrel shifter circuit diagram is made up of four 4x1 multiplexers . In the image, two selection lines, S0 and S1, are shown, as well as the input and output from bottom to top.

Figure shows the schematic of a 4-bit barrel shifter built with four 4x1 multiplexers. Voltage sources such as vpulse are used to substitute input pins (w3, w2, w1, w0) and selection lines (S1, S0), while outputs are taken at y3, y2, y1, y0. In this design , all the operations are carried as mentioned in the truth table.



**Fig 6:** Universal 4-Bit PT Mux Based Barrel Shifter In FINFET

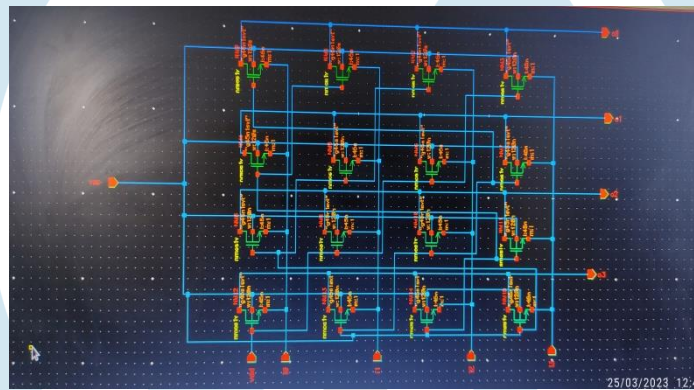
There are four inputs and four outputs. Shifts in inputs appear at the output based on the control word delivered at S1 and S0. Within a single clock pulse, up to (n-1) shifts for a n bit barrel shifter can be obtained.

$s_1$	$s_0$	$y_3$	$y_2$	$y_1$	$y_0$
0	0	$w_3$	$w_2$	$w_1$	$w_0$
0	1	$w_0$	$w_3$	$w_2$	$w_1$
1	0	$w_1$	$w_0$	$w_3$	$w_2$
1	1	$w_2$	$w_1$	$w_0$	$w_3$

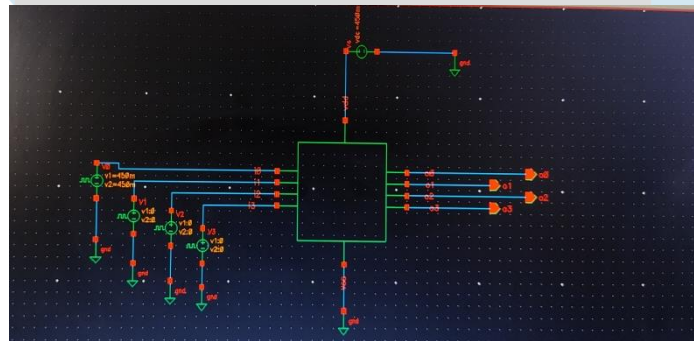
**Table-1:** Truth Table of 4×4 Barrel Shifter

### III. ANALYSIS AND SIMULATION RESULTS

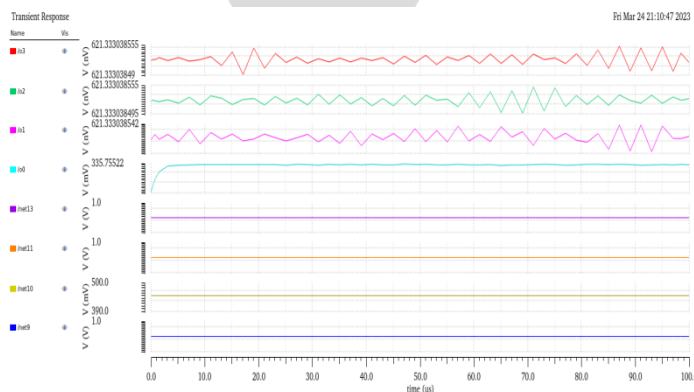
#### Schematic Level of CMOS 4×4 Crossbar Barrel Shifter



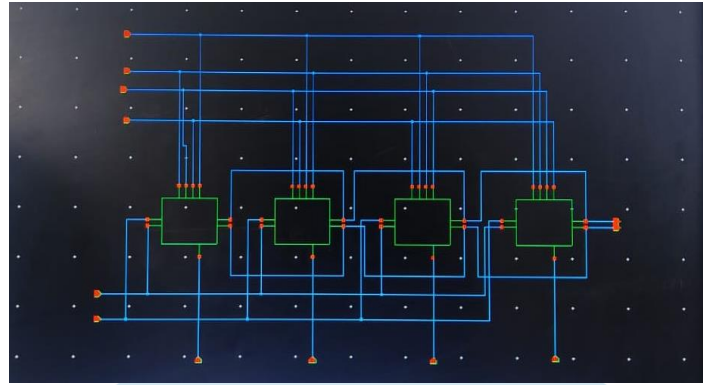
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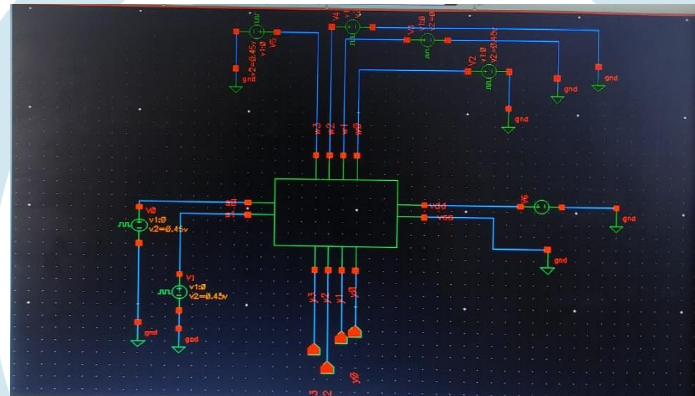
#### Input And Output of CMOS 4×4 Barrel Shifter



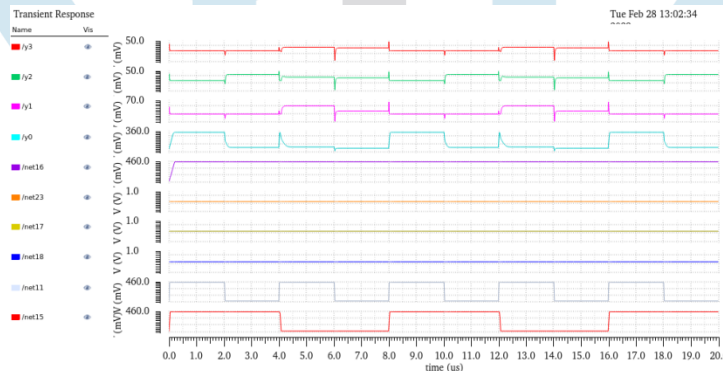
Schematic Level of PT MUX Based Barrel Shifter Using FINFET



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Input And Output of 4-Bit PT MUX Based Barrel Shifter Using FINFET



VI CONCLUSION

The power of eight different multiplexer implementation strategies has been studied. The highest power dissipation of PT is obtained by adopting FINFET technology at the 16nm node. This is lower because time is more important in FinFET-based PT Mux. With the FINFET 16nm technology, one distinct approach was successfully tested. This analysis demonstrates that the performance of PT Mux is excellent. varies, and exact mux can be selected according to the designer's requirements to optimise the overall performance of the circuit design. A total of four transistors are used to operate a PT-based Mux. The 4×4 cross barrel shifter is designed with CMOS 45nm technology, while the The global 4-bit barrel shifter is built with FINFET 16nm node PT based multiplexers. The average power of a 4×4 barrel shifter is 335.8PW, while the average power of a 4-bit barrel shifter PT based mux in FINFET is 104.0PW.

S.NO	Topology	Power Consumption
1	4×4 Barrel Shifter Using	335.8PW

	CMOS	
2	PT Based Mux Barrel Shifter Using FINFET	104.0PW

## VII FUTURE SCOPE

The research of a barrel shifter employing MOSFETs reveals that it cannot be scaled down in technology node after a certain point, and that further improvement in power performance is not achievable. So, In today's context, FINFET is one of the best alternatives for improving barrel shifter performance with reduced power consumption and area consideration.. A barrel shifter is a critical component of ALUs, microprocessors, and other computational devices that require data shifting and rotation. Improving the barrel shifter immediately benefits the source design. A barrel shifter is built and evaluated in this study using FINFET at the 16nm technology node, revealing promising advances in performance with less area required and lower power dissipation.

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