COMPARISON OF SIXTEEN BIT BARREL AND LOGARITHMIC SHIFTERS

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Project Proposal

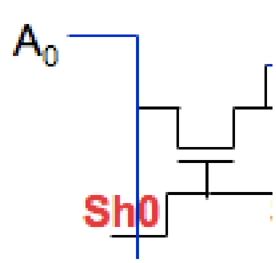
Description

The shift operation is an essential arithmetic and logic operation to modern computing. It involves shifting the bits of a number to the left or right by a certain amount. The shift operation is important in many operations including multiplication, division, scalers, and floating-point units. A simple shift by a constant amount can have the wires simply rerouted on the chip, but often a programmable shifter is required. A programmable shifter is supplied in the hardware by using transistors to form complex multiplexers. Two of the most common shift structures include the barrel shifter and the logarithmic shifter.

We are concerned about comparing these two types of shifters. We will look at both a sixteen bit barrel shifter and a sixteen bit logarithmic shifter. Their speeds and relative size will be compared to see which would be ideal for various applications.

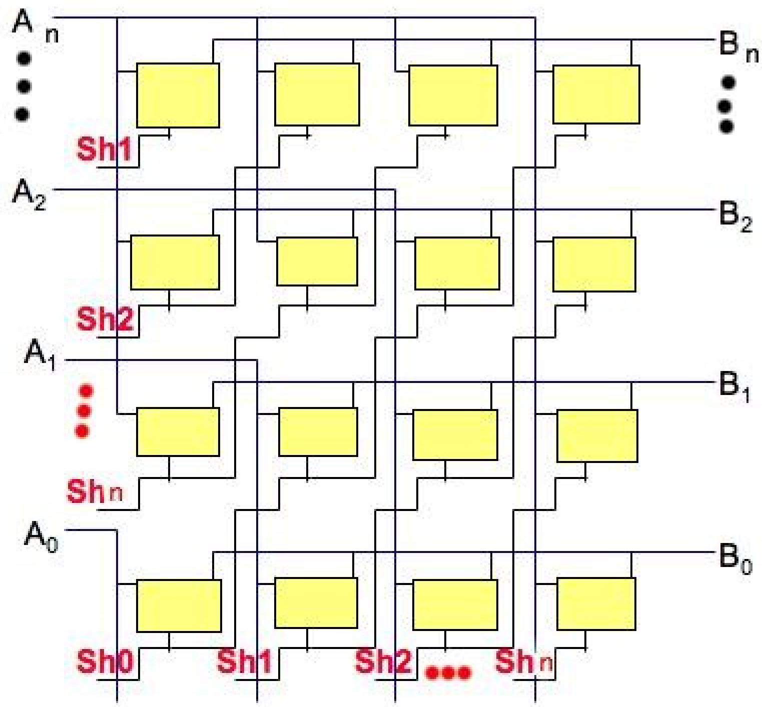
Barrel Shifter

A barrel shifter is made up of an array of transistors in which the number of rows equals the number input bits and the number of columns equals the number of bits that can be shifted. This requires an input signal that is equal to the number of columns there are. With a barrel shifter, the dominant factor for size is the massive amount of wiring that is required, although the number of transistors an input signal must pass through is equal to one. The basic building block of the barrel shifter that makes up the array is as follows:



Basic Building Block of Barrel Shifter

With this knowledge, we know that our basic layout of our barrel shifter will look like the following, using the basic building block above. This will result in a total of n^2, or $16^2 = 256$ basic building blocks.

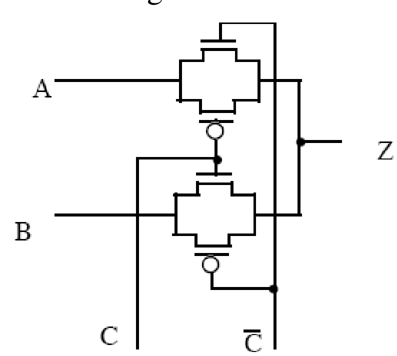


Basic Layout of an N-bit Barrel Shifter Using the Basic Building Blocks

Logarithmic Shifter

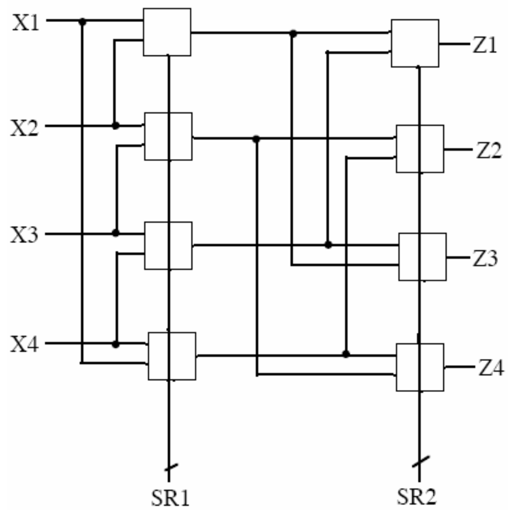
In logarithmic shifters, the total shift value is decomposed into shifts over powers of two. A shifter with a maximum shift width of M consists of a log2(M) stages, where the i-th stage either shifts over 2^i or passes the data unchanged. An n-input logarithmic shifter is comprised of a 2-dimensional array of either transmission gates or multiplexors having n-rows and $\log_2(n)$ columns. The columns of the matrix determine the number of shifts to be performed on the input. The control bits are encoded for this shifter, and each shift handles a magnitude of two (choosing whether or not to shift the data at that stage). With $\log_2(n)$ stages, log shifters should be quite useful for applications with many inputs, and the actual design of the chip requires a relatively minimal amount of wiring.

With complimentary inputs, each building block of the MUX array will look like:



Basic Building Block of a Logarithmic Shifter using MUX architecture

Expanding upon this concept, a 4-bit logarithmic shifter will look like:



Basic Layout of 4-bit Logarithmic Shifter using building blocks

This design will be expanded to fit sixteen inputs, thereby having $\log_2(16) = 4$ multi-select inputs to determine the number of shifts. This will result in a total of 64 basic building blocks, feeding to a sixteen bit output.

Roles Plans

Bryan Cover: Implementation of Barrel Shifter
Brian Ghigiarelli: Implementation of Logarithmic Shifter

References

Irwin, Mary J. "Lecture 22: Shifters, Decoders, Muxes." CSE 477: VLSI Digital Circuits. Penn State. 2003. 14 Feb. 2007 <http://mdlwiki.cse.psu.edu/twiki/pub/MDL/MJI477/cse477-22shifters.ppt>.

Rabaey, Jan M., Anantha Chandrakasan, and Borivoje Nikolic. Digital Integrated Circuits. Second ed. Upper Saddle River: Pearson Education, Inc., 2003. 594-596.