Implementation of Low Power Delay Pulsed Latches for Shift Register Using KOGGE Stone Adder

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Abstract: This project proposes delay efficient architecture for shift registers using pulsed latches instead of flip flops. Area and power can be reduced greatly by using latches then flip flops. The timing problem exhibited by the latches is reduced by taking necessary delays in pulses for latches. This includes a counter for generating pulses with delays. For obtaining these delays counter has to incremented by 1. The proposed kogge stone architecture reduces the delay to maximum extent, and produces numerous variation between conventional adder architecture.

Keywords: Flip Flops; Latches; Kogge Stone Adder;

1. INTRODUCTION

Dynamic power is consumed across all elements of a chip. The clock network is one of the large consumers of dynamic power. Therefore, reducing power in the clock network can impact the overall dynamic power significantly. Designers already use a variety of techniques to reduce the clock power using smaller clock buffers. Even with these techniques, the dynamic power of clock network can be large since registers are used as state elements in the design. In general, a flip-flop is used as the register.

A conventional flip-flop is composed of two latches (master and slave) triggerd by a clock signal. Flip-flop synchronization with the clock edge is widely used because it is matched with static timing analysis (STA). Timing optimization based on STA is must for SoCs. A methodology has been developed which uses latches triggered with pulse clock waveforms. With this methodology, designers can apply static timing analysis and timing optimization to a latch design while reducing the dynamic power of the clock networks.

II. PULSE LATCH

The pulsed latch requires pulse generators that generate pulse clock waveforms with a source clock. The pulse width is chosen such that it facilitates the transition. The following diagram represents a simple pulse generator and the associated pulse waveform.

In this methodology, the pulse generators are automatically inserted to satisfy several rules during clock-tree synthesis. Along with pulse generators, this approach also uses a number of matching delay cells to allow for match clock insertion delays with or without pulse generators.

2.1 Shift registers:

Flip flops are use in constructing registers. Register is a group of flip flops used to store multiple bits of data. For example, if a computer is to store 16 bit data, then it needs a set of 16 flip flops. The input and outputs of a register are may be serial or parallel based on the requirement. A shift register is a sequential circuit which stores the data and shifts it towards the output on every clock cycle. Basically shift registers are of 4 types. They are

- Serial In Serial Out shift register
- Serial In parallel Out shift register
- Parallel In Serial Out shift register
- Parallel In parallel Out shift register

2.1.1 Parallel in Serial out shift register:

The input to this register is given in parallel i.e. data is given separately to each flip flop and the output is collected in serial at the output of the end flip flop.

The clock input is directly connected to all the flip flops but the input data is connected individually to each flip flop through a mux (multiplexer) at input of every flip flop. Here D1, D2, D3 and D4 are the individual parallel inputs to the shift register. In this register the output is collected in serial.
Fig2.2 : Parallel In serial out Shift Register
The output of the previous flip flop and parallel data input are connected to the input of the MUX and the output of MUX is connected to the next flip flop. A Parallel in Serial out (PISO) shift register converts parallel data to serial data. Hence they are used in communication lines where a number of data lines are multiplexed into single serial data line.

Fig2.3: shift registers with latches and pulsed clock signal
A master-slave flip-flop using two latches can be replaced by a pulsed latch consisting of a latch and a pulsed clock signal. All pulsed latches share the pulse generation circuit for the pulsed clock signal. As a result, the area and power consumption of the pulsed latch becomes almost half of those of the master-slave flip-flop. The pulsed latch is an attractive solution for small area and low power consumption. The pulsed latch cannot be used in shift registers due to the timing problem. The shift register consists of several latches and a pulsed clock signal (CLK_pulse). The operation waveforms show the timing problem in the shifter register. The output signal of the first latch (IN) is constant during the clock pulse width. But the second latch has an uncertain output signal (Q2) because its input signal (Q1) changes during the clock pulse width. One solution for the timing problem is to add delay circuits between latches, as shown in Fig. 3(a). The output signal of the latch is delayed and reaches the next latch after the clock pulse. As shown in Fig. 3(b) the output signals of the first and second latches (Q1 and Q2) change during the clock pulse width, but the input signals of the second and third latches (D2 and D3) become the same as the output signals of the first and second latches (Q1 and Q2) after the clock pulse. As a result, all latches have constant input signals during the clock.

III. PULSED LATCH ARCHITECTURE
The power optimization is similar to the area optimization. The power is consumed mainly in latches and clock-pulse circuits. Each latch consumes power for data transition and clockloading. When the circuit powers are normalized with a latch, the power consumption of a latch and a clock-pulse circuit are 1 and 2, respectively. The total power consumption is also.

The pulsed clock signals are supplied to all sub shift registers. Each pulsed clock signal arrives at the sub shift registers at different time due to the pulse skew in the wire. The pulse skew increases proportional to the wire distance from the delayed pulsed clock generator. All pulsed clock signals have almost the same pulse skews when they arrive at the same sub shift register. Therefore, in the same sub shift register, the pulse skew...
differences between the pulsed clock signals are very small. The clock pulse intervals larger than the pulse skew differences cancel out the effects of the pulse skew differences. Also, the pulse skew differences between the different sub shift registers do not cause any timing problem, because two latches connecting two sub shift registers use the first and last pulsed clocks (CLK_pulse(T) and CLK_pulse(1)) which have a long clock pulse interval.

3.1 Delayed clock pulse generator:

In a long shift register, a short clock pulse cannot through a long wire due to parasitic capacitance and resistance. At the end of the wire, the clock pulse shape is degraded because the rising and falling times of the clock pulse increase due to the wire delay. A simple solution is to increase the clock pulsewidth for keeping the clock pulse shape. But this decreases the maximum clock frequency. Another solution is to insert clock buffers and clock trees to send the short clock pulse with a small wire delay. But this increases the area and power overhead.

Moreover, the multiple clock pulses make the more overhead for multiple clock buffers and clock trees.

3.2. Ripple carry adder

A ripple carry adder is simply several full adders connected in a series so that the carry must propagate through every full adder before the addition is complete. Ripple carry adders require the least amount of hardware of all adders, but they are the slowest.

The following diagram shows a four-bit adder, which adds the numbers A[3:0] and B[3:0], as well as a carry input, together to produce S[3:0] and the carry output.

3.4 Propagation Delay in Full Adders

Real logic gates do not react instantaneously to the inputs, and therefore digital circuits have a maximum speed. Usually, the delay through a digital circuit is measured in gate-delays, as this allows the delay of a design to be calculated for different devices. AND and OR gates have a nominal delay of 1 gate-delay, and XOR gates have a delay of 2, because they are really made up of a combination of ANDs and ORs.

A full adder block has the following worst case propagation delays:

- From A_i or B_i to C_{i+1}: 4 gate-delays (XOR → AND → OR)
- From A_i or B_i to S_i: 4 gate-delays (XOR → XOR)
- From C_i to C_{i+1}: 2 gate-delays (AND → OR)
- From C_i to S_i: 2 gate-delays (XOR)

Because the carry-out of one stage is the next’s input, the worst case propagation delay is then:
• 4 gate-delays from generating the first carry signal ($A_0/B_0 \rightarrow C_1$).
• 2 gate-delays per intermediate stage ($C_i \rightarrow C_{i+1}$).
• 2 gate-delays at the last stage to produce both the sum and carry-out outputs ($C_{n-1} \rightarrow C_n$ and $S_{n-1}$).

So for an $n$-bit adder, we have a total propagation delay, $t_p$, of:

This is linear in $n$, and for a 32-bit number, would take 66 cycles to complete the calculation. This is rather slow, and restricts the word length in our device somewhat. We would like to find ways to speed it up.

IV. KOGGE-STONE ADDER

The Kogge–Stone adder is a parallel prefix form carry look-ahead adder. Other parallel prefix adders include the Brent-Kung adder, the Han Carlson adder, and the fastest known variation, the Lynch-Swartzlander Spanning Tree adder.

The Kogge–Stone adder takes more area to implement than the Brent-Kung adder, but has a lower fan-out at each stage, which increases performance for typical CMOS process nodes. However, wiring congestion is often a problem for Kogge–Stone adders. The Lynch-Swartzlander design is smaller, has lower fan-out, and does not suffer from wiring congestion; however to be used the process node must support Manchester Carry Chain implementations.

The general problem of optimizing parallel prefix adders is identical to the variable block size, multi level, carry-skip adder optimization problem, a solution of which is found in.

An example of a 4-bit Kogge–Stone adder is shown in the diagram. Each vertical stage produces a "propagate" and a "generate" bit, as shown. The culminating generate bits (the carries) are produced in the last stage (vertically), and these bits are XOR’d with the initial propagate after the input (the red boxes) to produce the sum bits. E.g., the first (least-significant) sum bit is calculated by XOR’ing the propagate in the farthest-right red box (a "1") with the carry-in (a "0"), producing a "1". The second bit is calculated by XOR’ing the propagate in second box from the right (a "0") with CO (a "0"), producing a "0".

Enhancements to the original implementation include increasing the radix and sparsity of the adder. The radix of the adder refers to how many results from the previous level of computation are used to generate the next one. The original implementation uses radix-2, although it's possible to create radix-4 and higher. Doing so increases the power and delay of each stage, but reduces the number of required stages. The sparsity of the adder refers to how many carry bits are generated by the carry-tree. Generating every carry bit is called sparsity-1, whereas generating every other is sparsity-2 and every fourth is sparsity-4. The resulting carries are then used as the carry-in inputs for much shorter ripple carry adders or some other adder design, which generates the final sum bits. Increasing sparsity reduces the total needed computation and can reduce the amount of routing congestion.
VI. SIMULATION RESULT

Fig: simulation results and related timing diagram

VII. CONCLUSION
This project proposes delay efficient shift register by using pulsed latches. Pulsed latches gives the same results similar to the flip flops but with less hardware resources. Flip flops need two latches. The same results can be obtained by using a clocked latch with pulse signal as clock input. This reduces the hardware requirement, in addition to this for producing different clock pulses for latches this project uses counter architecture for activating the latches. In this, counter is the circuit that increments its previous value by 1. In the increasing process several adders are implemented. This project proposes kogge stone adder which reduces ¾ of the conventional adder takes 3.497 nano seconds where as the pulsed latch takes 0.932 nano seconds. The same results can be obtained by using pulsed latches. Pulsed latches gives the same results similar to the flip flops but with less hardware resources. Flip flops need two latches. The same results can be obtained by using a clocked latch with pulse signal as clock input. This reduces the hardware requirement, in addition to this for producing different clock pulses for latches this project uses counter architecture for activating the latches. In this, counter is the circuit that increments its previous value by 1. In the increasing process several adders are implemented. This project proposes kogge stone adder which reduces ¾ of the conventional adder takes 3.497 nano seconds where as the pulsed latch takes 0.932 nano seconds.

VIII. REFERENCES