

A Novel Design of High Speed and Area Efficient De-Multiplexer Using Pass Transistor Logic

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ABSTRACT:

Speed and the overall performance of any digital signal processor are largely determined by the efficiency of the de-multiplexer units present within. The use of pass transistor logic has resulted in significant improvement in the performance of de-multiplexer architectures used for high speed computing. This paper proposes 1 to 2, 1 to 4 and 1 to 8 de-multiplexer architectures based on pass transistor logic. These low power designs are realized in 65 nm CMOS Process technology using Microwind and DSCH 3.5 tool. This research paper analyses the performance of De-Multiplexer (De-Mux) using Pass Transistor Logic Configuration (PTLC) and CMOS Logic Configuration (CLC).

Furthermore, a comparison between the performances of both the configurations in terms of power and area. Besides this, paper also signifies more than 50% decrement in area and number of transistors count while using pass transistor logic configuration in comparison to de-multiplexer implemented with CMOS logic configuration. Moreover, reduction in power dissipation up to 70% is observed in pass transistor logic comparing to CMOS logic.

Keywords—CMOS logic configuration, De-multiplexer, Pass transistor logic, Power dissipation, Chip area.

INTRODUCTION

A de-multiplexer (De-Mux) is a combinational digital circuit that has one input and more than one output. It is used when a circuit wishes to send a signal to one of many devices [1]. In this paper, the effect of change in architecture of 1:2, 1:4 and 1:8 de-multiplexer in terms of power dissipation and area. The schematic diagram and characteristic table for 1:2 de-multiplexer is shown in Fig. 1 (a) and (b), respectively. It is observed from the diagram that 1:2 de-multiplexer has one input line IN and one select line S, whereas, OUT1 and OUT2 are the two outputs. When S is in logic state 1 (high) output line OUT2 is selected and reflects input at terminal A. Similarly, when S is logic- 0 (low) output line OUT1 is selected and input at IN reaches output line OUT1. The 1:2 de-multiplexer logic is implemented using gate level configuration that includes two-logic gate and one inverter circuit [1].

The observed result indicates that the power dissipation, chip area, output current level and other parameters vary with change in transistor technology node or architecture. This research paper analyses the behavior of 1:2 de-multiplexer in pass transistor logic and conventional CMOS logic architecture using Microwind and DSCH simulation. The Technology

node and supply voltages of 65nm and 1.0V are considered from experimental results respectively so that all architecture/configurational impact can be measured significantly with respect to different architectures.

The results show that the 1:2 de-multiplexer logic implementation in pass transistor logic architecture perform better in comparison to CMOS logic configuration mainly in terms of area consumption, number of transistor counts, supply voltage and power dissipation.

TABLE I. CHARACTERISTIC TABLE FOR 1:2 DE-MULTIPLEXERS.

Select Line (S)	Input (IN)	Outputs	
		Out1	Out2
0	0	0	0
0	1	1	0
1	0	0	0
1	1	0	1

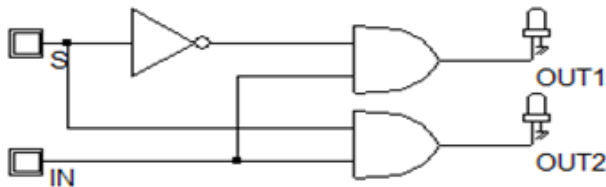
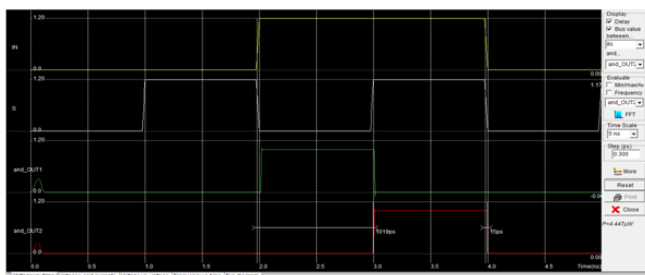


Fig.1. Simulated gate level structure and Characteristic for 1:2 de-multiplexer (a) gate level structure



(b) Input and output voltage results.

CMOS LOGIC IMPLEMENTATION

CMOS logic architecture is one of the most commonly used logic configuration employed in digital circuit designing but it has its own merits and demerits. Few are described here such as large numbers of transistors

are required even to implement simple circuits like basic logic gates and inverter circuit. Fig. 2 depicts CMOS architecture of 1:2 de-multiplexers [2]. It is clear from the diagram that 14 transistors are required to implement this device. Six transistors for each AND gate and two for NOT gate, where S is selection line. The IN is input that is applied to both the AND gates. OUT1 and OUT2 represent output lines. The selection of these lines is dependent on terminal S. It can also be understood from the figure that large number of interconnects are used in this approach to connect numerous transistors. Therefore, CMOS logic is easy to design but very resource consuming [3].

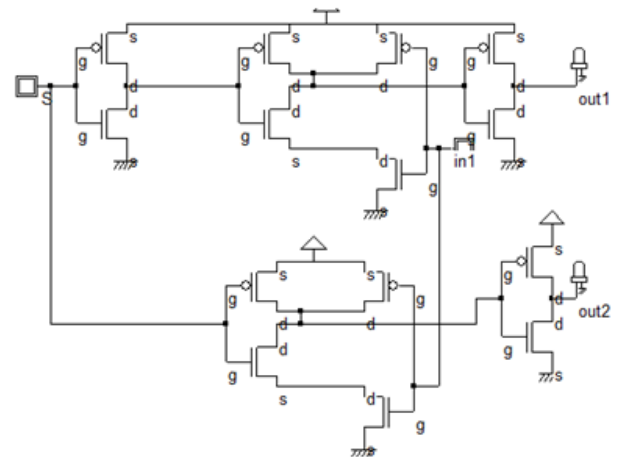


Fig.2. Schematic diagram of CMOS logic configuration of 1:2- de-multiplexer

PASS TRANSISTOR LOGIC ARCHITECTURE

The implementation of 1:2 de-multiplexer using pass transistor logic configurations is required only six transistors to implement the complete logic architecture. This means that number of transistors used in pass transistor architecture is less than 50% (Half) of the transistors utilized in CMOS architecture. Therefore, it is evident from the facts stated. Figure 3, show that the area consumption is 50% less using pass transistor logic architecture. Moreover, lesser interconnect lengths and fewer transistors allows a decrement in fabrication cost too. Moreover, the fabrication steps and resources are also decreased/ consumed less in pass transistor logic implementation. Therefore, results observed in both the architecture is

stated that pass transistor architecture is more area efficient than ordinary CMOS architecture [2-5].

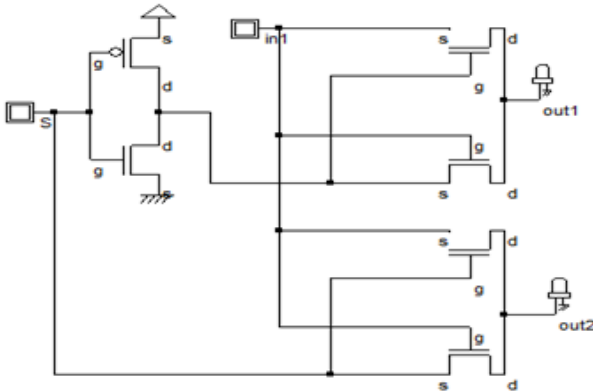


Fig. 3. Schematic diagram of pass transistor logic configuration of 1:2 demultiplexers.

REDUCTION IN SUPPLY VOLTAGE

Normally in all the cases average power dissipation of CMOS and MOS logic implementations is directly dependent on the supply voltage. This statement can be verified by Eq. (2).

$$P_{avg} = C_{load} \cdot V_{DD}^2 \cdot f_{clk} \quad (1)$$

It is clear from Eq. (1) that supply voltage, VDD is directly proportional to the average power dissipation, Pavg of the transistor. Any change in supply voltage is directly reflected on to the power dissipation. It is observed and discussed in Section IV that for the constant supply voltage pass transistor logic architecture is providing double current than CMOS logic architecture.

Therefore pass transistor logic architecture reduce its supply voltage to an extent, when output current levels of both the architectures are same. This condition will further enable us to compare their power dissipation for similar output current. By Ohm's law, if reducing the supply voltage from 1.0V to 1.8V for pass transistor logic architecture. Now power dissipation can be compared of the architectures as both are having similar output current level.

ANALYSIS OF POWER DISSIPATION AND PERFORMANCE COMPARISON FOR CMOS AND PASS TRANSISTOR LOGIC

The power dissipation can be compared of the architectures as both are having similar output current levels. Power dissipation is the most important characteristic of any device in the era of portable devices, where most of the systems are working on a battery that has limited supply/backup time. Moreover, battery technology is not been able to cope-up with the transistor technology changes in recent times due to which a rift has been generated between power consumed by the device and power available to use. This gap can be fulfilling by the low power VLSI design methodologies that can reduce/control the power dissipation of the devices [5-7]. CMOS is power efficient logic but by observing Eq. (2), it can deduce that 1:2 De-multiplexer design implementation using pass transistor logic can further reduce the power dissipation of the circuits.

$$P_{avg} = \left(\sum \alpha_{Ti} \cdot C_i \cdot V_i \right) \cdot V_{DD} \cdot f_{clk} \quad (2)$$

Where α_{Ti} is corresponding node transition factor, C_i is parasitic capacitance associated with each node, V_i is node voltage, VDD is supply voltage and f_{clk} is clock frequency. It is prominent from the equation that number of operating nodes also contribute to the overall power dissipation of the device. Since CMOS logic implementation requires larger number of transistors therefore operating points is higher in CMOS logic implementation than pass transistor logic implementation. Another important point i.e. supply voltage of pass transistor logic architecture. It is reduced by 33% (0.6V) making it further power efficient. Apart from Eq. (1) and (2) & Fig. 4 and 5 are also confirming our observation. Figure 4, indicate that maximum power dissipation of a transistor in CMOS logic architecture is increased to the level of 20μW that is also proved the Eq. (1) and (2). Moreover, it is the power dissipation of only one transistor. The overall power dissipation will be much more due to large number of transistor utilized in CMOS logic architecture implementation.

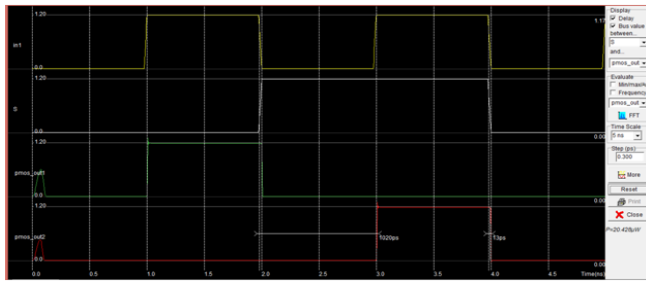


Fig. 4. Characteristic curve of power dissipation for CMOS architecture and pass transistor architecture of 1:2 de-multiplexer 1.8V VDD.

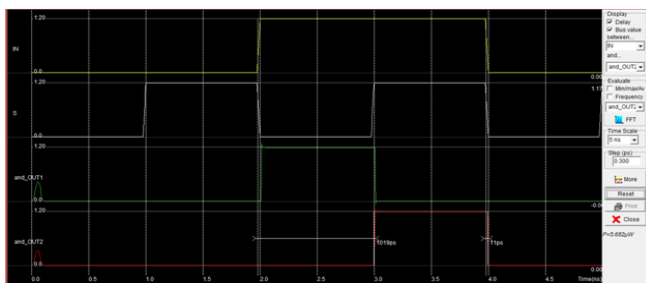


Fig. 5. Characteristic curve of power dissipation for pass transistor architecture of de-multiplexer 1:2 at 1.2V VDD.

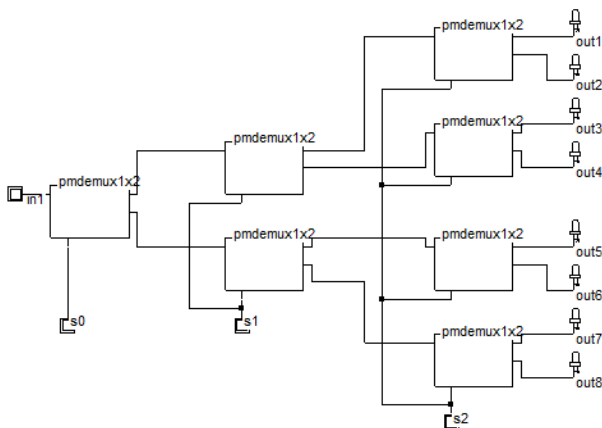


Fig. 6. Schematic diagram of pass transistor logic configuration of 1:2 demultiplexers.

On the other side, the pass transistor logic architecture characteristic wave form shown in Fig. 5, wherein, the power dissipation of individual transistors has an upper level only $5.6\mu\text{W}$, that is 16 times less in comparison to the CMOS architecture. Moreover, the total number of transistors is 50% less (means half) in comparison to its counterpart (CMOS logic) that enhances the power efficiency. Besides this, 1:2 de-multiplexer

architecture implementation using pass transistor logic configuration is more power efficient. Finally, to achieve an overall improved performance, the 1:2 de-multiplexer architecture is designed such that the pass transistor logic architecture are based on 6-transistors instead of often used conventional CMOS logic.

TABLE. II. COMPARISON OF PERFORMANCE PARAMETERS FOR CMOS AND PASS TRANSISTOR LOGIC CONFIGURATIONS

S.No.	Parameters	Pass Transistor Logic	CMOS Logic
1	Number of transistors	6T	14T
2	Power(vdd=1.20v)	4.65uw	20.360uw
3	Delay	2.1ns	12.2ns

CONCLUSION

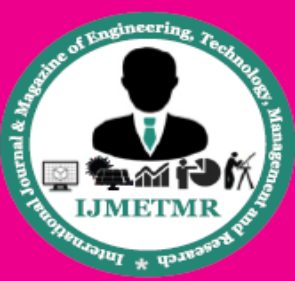
This paper analyzed the performance of 1:2 De-Mux using PTLA and CLA. The results observed that approximately 50% of chip area is saved by using the pass transistor logic configuration as only six transistors (6-T) are employed to implement the 1:2 de-multiplexer while fourteen transistors (14-T) are used in CMOS logic architecture. The power supply is reduced by 33% observed due to processes with pass transistor logic. Moreover, 70% reduction in power dissipation is analyzed with pass transistor. Therefore, it can be concluded that the pass transistor logic implementation of 1:2 de-multiplexer gives better performance and consumes less chip area in comparison to CMOS logic architecture.

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