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High Speed Voltage Follower using DTMOS Transistor

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Abstract — *This paper describes class-A voltage followers Basic Source Follower using MOS and DTMOS Transistor. The circuits are simulated in 90nm technology. The results are used to compare the performance of the different voltage followers. All analysis are supported by the simulation results. Class-A voltage followers are designed in 90nm technology. The analysis are made in terms of transient response and frequency response using ELDO spice and mentor graphics. The propagation delay in MOS Transistor is more than DTMOS Transistor. So,the speed of the DTMOS is more than MOS Transistor. It is found that the Power Dissipation is reduced and Frequency can be improved.*

Keywords- *Voltage Follower, Buffer, Basic Source Follower, Dynamic Threshold MOS.*

I. INTRODUCTION

As the CMOS process entering the nano scale analog circuits will need to operate in lower supply voltage. Due to scale down technology supply voltage do not scale linearly the V_T and V_{Dsat} is not scaled down linearly [3].These serious limit the voltage swing in low voltage supply. Voltage Follower is a basic analog circuit in which output voltage follows the input voltage and it is also known as unity gain amplifiers. Voltage Follower mainly used as impedance matching circuit and Level shifter.

BJTs, MOSFETs, OP-AMPs can be used for the design of voltage follower. Voltage Follower must be satisfy the certain requirements.

- High input impedance,
- Low output impedance,
- High bandwidth,
- Low power dissipation,
- Linearity and Unity voltage gain,
- High output voltage swing means Gain must have to be unit

In DTMOS body terminal is tied to the gate terminal making V_T a function of the gate voltage. A MOS transistor with dynamic body bias technique is known as dynamic threshold MOS (DTMOS) transistor.

II. VOLTAGE FOLLOWER

A Voltage Buffer Amplifier is used for transferring a voltage from a first circuit having a high output impedance level, to the second circuit with a low input impedance level. Voltage buffers are essential components in analog and mixed signal processing systems. It is especially used for applications where low signal must be provided to a large capacitive load without being deformed to fulfil the demand; input capacitance of the buffer should be as low as possible. So, that weak signal is not affected by any circumstances. The output stage should have a high rate of rise, so the performance of the signal can remain driven at high capacitive loads. Voltage Follower implies the output will follows the input without any gain. The gain of the circuit is very nearly 1(unit). It is useful because its input resistance is very high. It is often used as a buffer between devices to avoid loading effects.

III. BASIC SOURCE FOLLOWER

The simplest design of voltage follower is the Basic Source Follower or Basic Voltage Follower. Basic Source Follower is a common drain amplifier circuit with unity voltage gain. The output at the source terminal follows the input applied which is at the gate. It is known as source follower. It is designed with PMOS and ideal current source. We can use current mirror instead current source. But, it does not assure that a constant amount of the current flows through the source terminal of the PMOS. It results into non-linearity in the output voltage. It also has high output impedance with low output impedance. In most design of voltage followers, all the transistors work in saturation region. Constant current must be ensured through the output path.

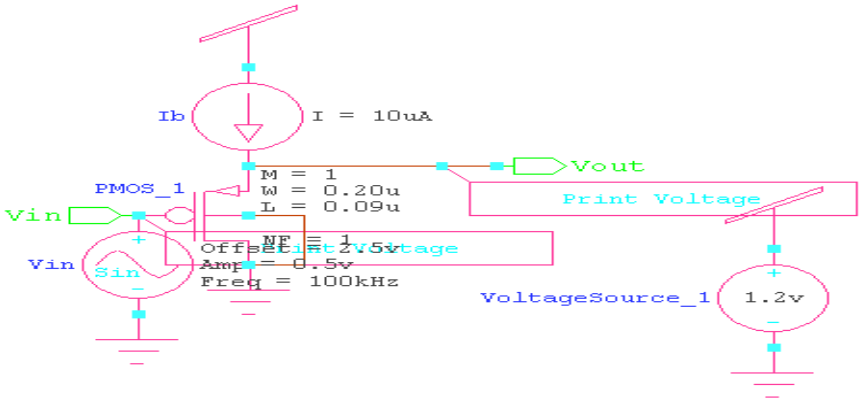

Fig.1: Basic Source Follower Design [1]

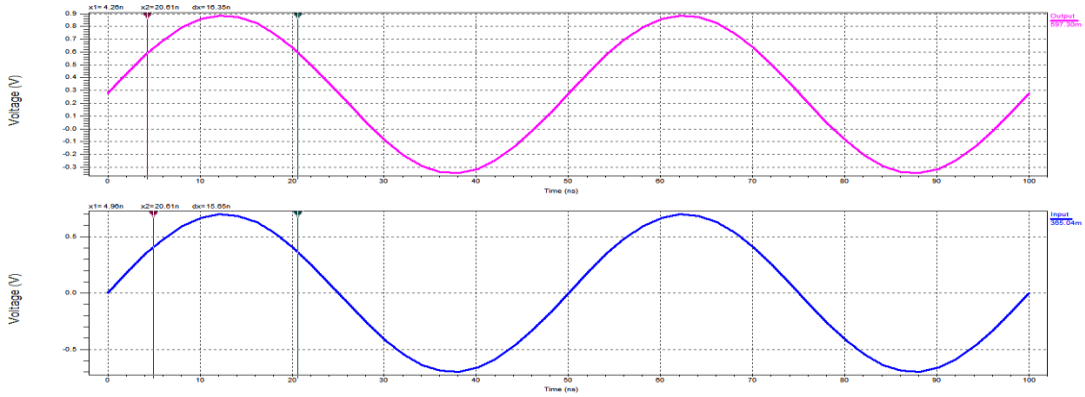

Fig.2: Transient Response of Basic Source Follower

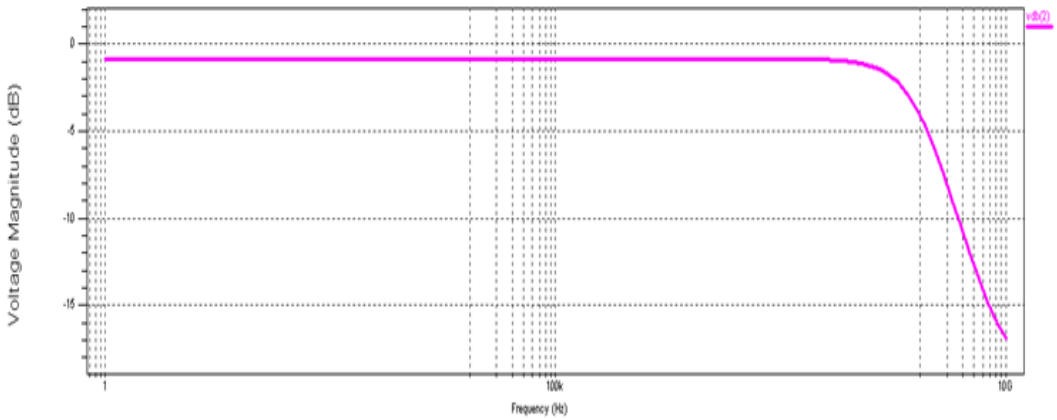

Fig.3: Frequency Response of Basic Source Follower

The voltage followers are easy to build. but, it has serious limitations.

- The current through M_1 of PMOS is highly depends on the output current. The result is behind the V_{GS} of M_1will being signal dependent. So, some distortions will be produced in output.
- The voltage buffers should drive a low resistance load. Thus, in order to gets a unity gain, the output resistance of the voltage follower should be very low.

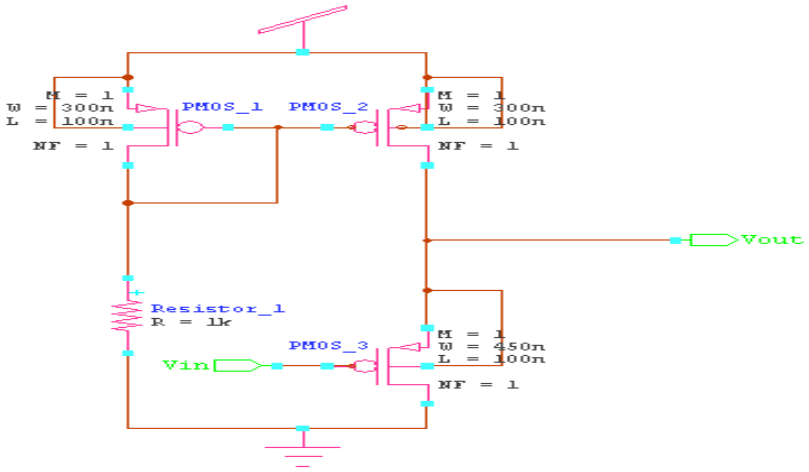

Fig.4: Basic Source Follower using Current Mirror Design[3]

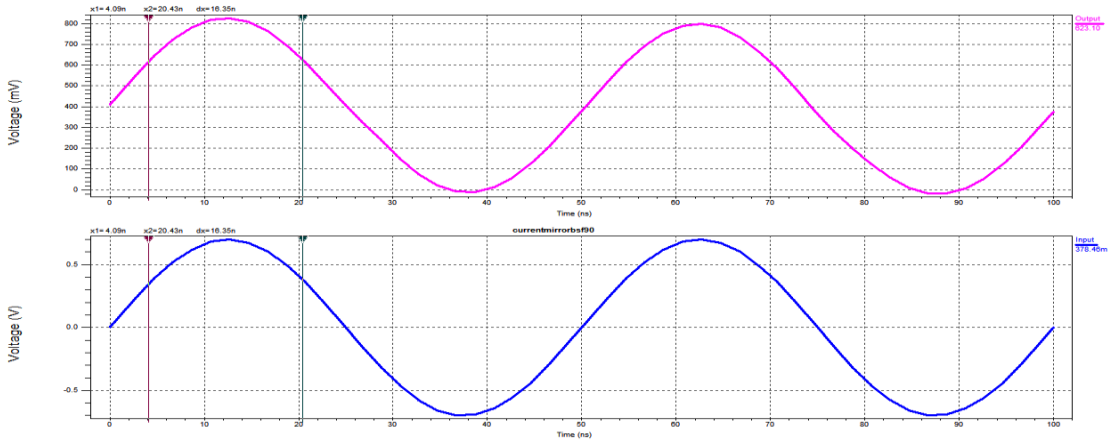

Fig.5: Transient Response of Basic Source Follower using Current Mirror

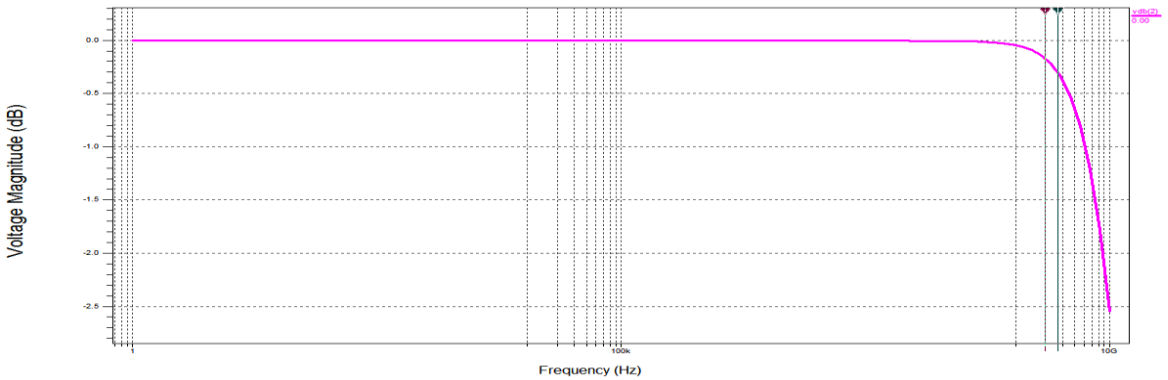

Fig.6: Frequency Response of Basic Source Follower using Current Mirror

Table I: Comparative Analysis of Basic Source Follower and Basic Source Follower using current mirror

Parameters	Basic Source Follower	Basic Source Follower using current mirror
Propagation Delay	20ns	16.5ns
Gain	0.15dB	0.0913dB
BandWidth	0.11GHz	0.12GHz
Power Dissipation(mW)	1.50	1.32

IV. DTMOS TRANSISTOR

A MOS transistor can be operated at a lower threshold voltage or higher threshold voltage by using various body biasing techniques reported in [4]. Body biasing techniques modulate the threshold voltage of MOS (V_T) transistor electrically by applying source-to-body voltage (V_{SB}) at body terminal as seen from following expression,

$$V_{TH} = V_{THO} + \gamma\left(\sqrt{\emptyset_s + V_{SB}} - \sqrt{\emptyset_s}\right) \quad \text{(1)}$$

Where, V_{TO} is the zero body bias threshold voltage and Mainly depends on the manufacturing process. y is the body effect coefficient (typically equals to $0.4V^{0.5}$) and it depends on the gate oxide capacitance, silicon permittivity, doping level and other parameters. $\emptyset_s$ is the surface potential at threshold (typically $|2\emptyset_F|$ equals 0.6 V). V_{SB} is the source-to- body voltage.

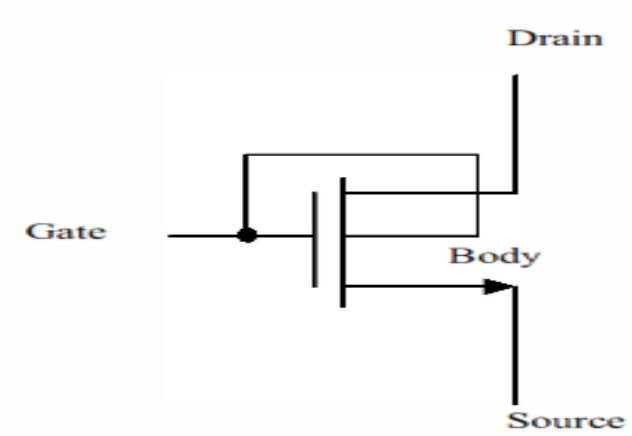

Fig.7: DTMOS Transistor

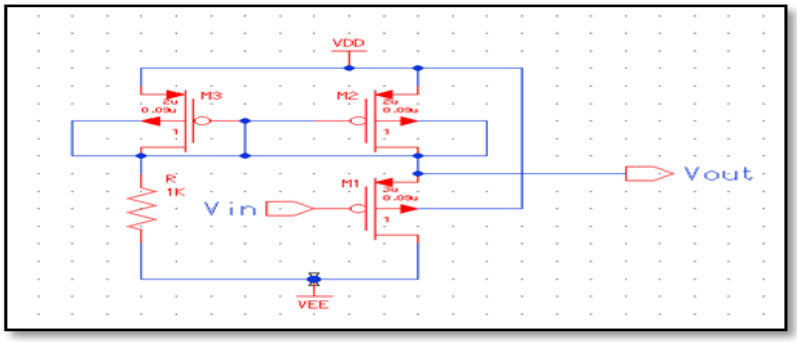

Fig.8: Basic Source Follower using DTMOS

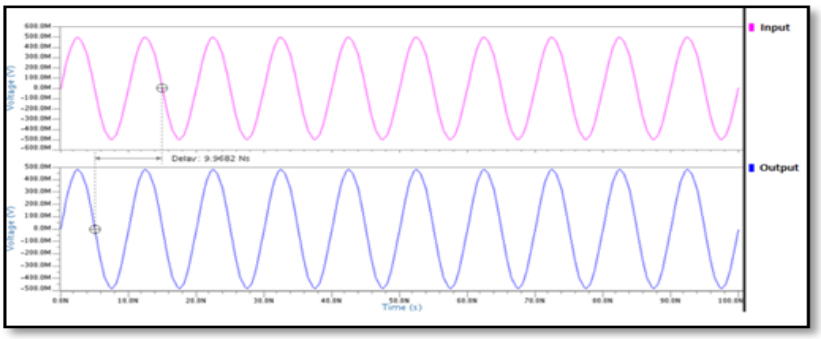

Fig.9: Transient Response of Basic Source Follower using DTMOS

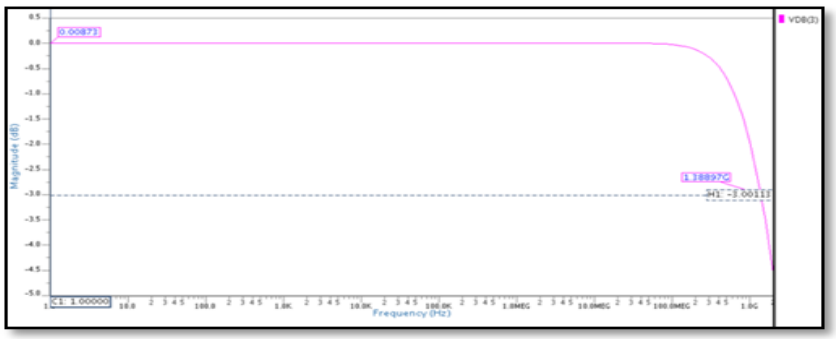

Fig.10: Frequency Response of Basic Source Follower using DTMOS

Table II: Comparative Analysis of Basic Source Follower and DTMOS Source Follower

Parameters	Basic Source Follower	DTMOS Basic Source Follower
Propagation Delay	16.5ns	9.9682ns
Gain	0.0913dB	0.00873dB
BandWidth	0.12GHz	0.14GHz
Power Dissipation(mW)	1.32	0.130

V. CONCLUSION

The simulation results for class-A voltage follower is presented using MOS and DTMOS Transistor in this paper in 90nm Technology. From the Table II, the propagation delay in MOS Transistor is more than DTMOS Transistor. So the speed of the DTMOS is more than MOS Transistor. It is found that the Power Dissipation is reduced and Frequency can be improved.

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