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Comparative analysis of different Current mirror using 45nm technology

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Abstract- Current mirror is one of the most important components of integrated analog circuits design. For high performance applications, accuracy, output impedance, slew rate and settling time of current mirrors are the most important parameters. The circuit made by current mode technique uses small area, consumes less power dissipation and achieves high operation speed. . In this paper we will analyze and compare the performance parameters of different current mirrors in 45 nm technology in Tanner EDA tool. The performance parameters are power dissipation, slew rate and Transconductance. The transconductance of proposed Low Voltage current mirror is far better than the other current mirrors.

Keywords— *Current mirror, current mode circuits, regulated cascade, negative feedback, transconductance.*

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1. INTRODUCTION

Current mirror circuits are well known in the art and have found uses in a variety of applications. Generally speaking, a current mirror circuit comprises a pair of transistors where an input reference current source is connected to drive one of the transistors. The pair of transistors are connected together in a manner whereby the reference current is substantially reproduced, or mirrored, at the output of the second transistor. In most cases, the critical factor in designing a current mirror circuit is providing optimum matching between the reference and output currents Current mirrors can also be formed using MOS devices In MOS technology, small channel length devices are increasingly in demand. In relation to current mirror circuits, the decrease in channel length results in the decrease of the output impedance of the current mirror. Cascoding techniques become necessary, therefore, to increase the output impedance [1].

When the current mirror is used as a load element in amplifiers, the high incremental resistance of current mirror provides high voltage gain at very low supply voltage. The current mirror uses the principle that if the gate-source potentials of two identical MOS transistors are equal, then the current flown through their Drain terminals should be the same [15].

The common application of current mirrors are as active load, as biasing element, current amplifier, operational amplifier, analog to digital converters, digital to analog converter and current conveyor etc[3]. There are many current mirrors available; following are the performance parameters of a current mirror:

2. DIFFERENT CURRENT MIRRORS

1. Simple current mirror

The basic current mirror can also be implemented using MOSFET transistors, as shown in Figure 2. Transistor M_1 is operating in the saturation or active mode, and so is M_2. In this setup, the output current I_{OUT} is directly related to I_{REF}.

The drain current of a MOSFET I_D is a function of both the gate-source voltage and the drain-to-gate voltage of the MOSFET. In the case of transistor M_1 of the mirror, $I_D = I_{REF}$. Reference current I_{REF} is a known current, and can be provided by a resistor as shown, or by a "threshold-referenced" or "self-biased" current source to ensure that it is constant, independent of voltage supply variations. Although the principle of operation for MOS transistors does not involve forward biasing of any diodes, *M*2 (i.e. MNMOS_1) is said to be diode connected. Assume that *M*1 (i.e. MNMOS_2) also operates in the active region and that both transistors have infinite output resistance. Then I_{D1} is controlled by V_{GS1}, which is equal to V_{GS2} by KVL. If the transistors are identical,

$$(W/L)_2 = (W/L)_1,$$

And therefore $I_{Out} = I_{D1} = I_{D2}$

The above equation shows that the current that flows in the drain of *M*2 is mirrored to the drain of *M*1. Since $\beta F \rightarrow \infty$ for MOS transistors, and KCL at the drain of *M*2 yield

$I_{OUT} = I_{D1} = I_{IN}$

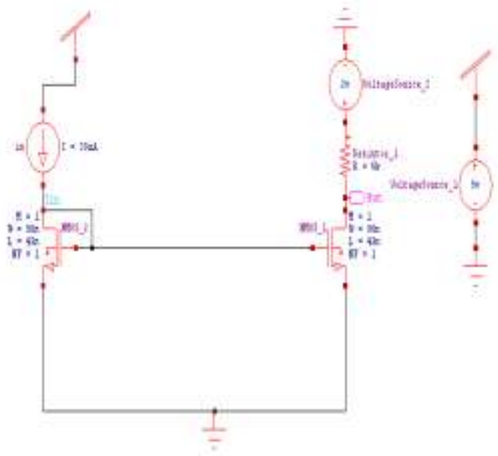

Fig 1: Simple current mirror circuit

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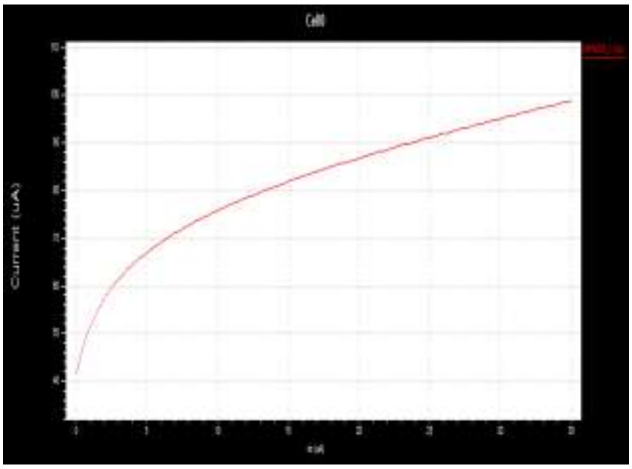

Fig 2: Simulated wave for simple current mirror

2. Conventional Regulated Cascode current mirror

Regulated cascode technique greatly increases the D.C. gain of cascode amplifier without sacrificing speed or output swing. Regulated Cascode current mirror produces more constant results than other cascode current mirror structures, here the concept of negative feedback is used, when voltage applied at NMOS_2 is increases its change in output is controlled by the NMOS_3 and NMOS_1because feedback loop is used and NMOS_2 works as source follower, thereby increasing the output resistance, hence we are getting constant current but there is a problem with regulated cascode current mirror is its output swing, which is limited because drain source voltage of NMOS_1 is never touches.

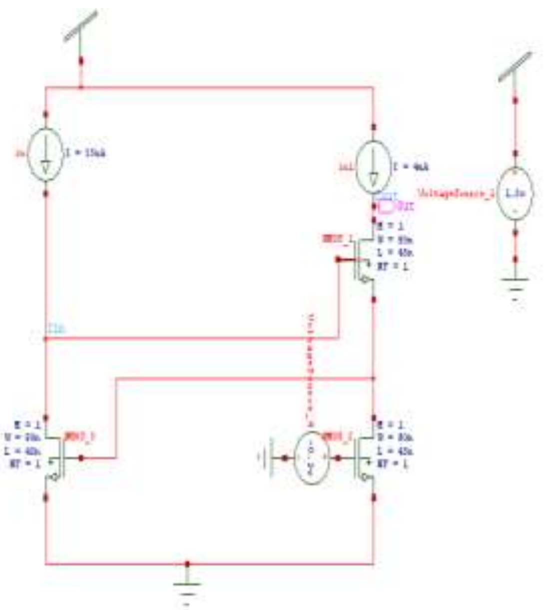

Fig 3: Conventional Regulated Cascode current mirror circuit

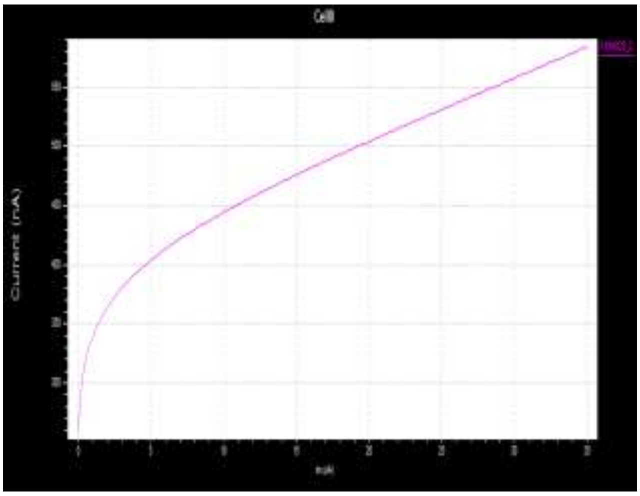

Fig 4: Simulated result for Conventional Regulated Cascode current mirror circuit

3.Cascode current mirror: A cascoded current mirror device is disclosed that is capable of producing an output current that is a direct function of an input current received by that device. The cascoded current mirror includes at least two portions connected together in a cascode manner. Provision is also made for feedback connection between those portions. This feedback connection can, for example, be a buffering connection. Voltage signals are generated by this device that can be used to drive and control additional output stages. Each such additional output stage is capable of producing an additional output current.

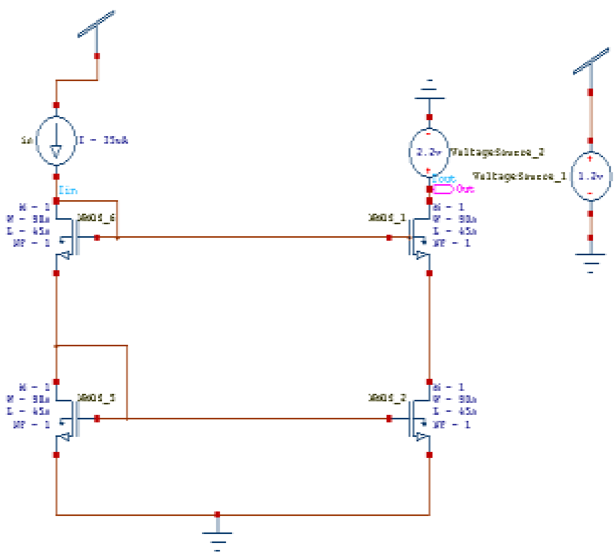

Fig 5: Cascode current mirror circuit

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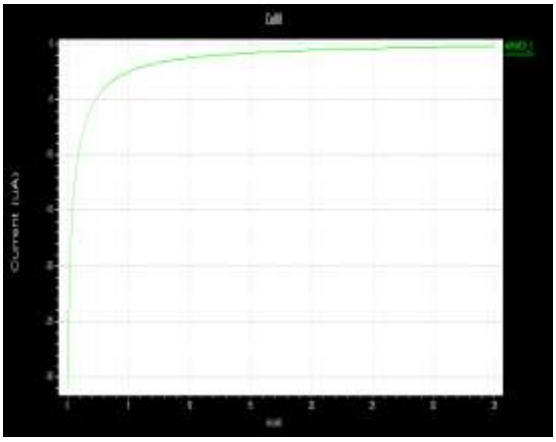

Fig 6: Simulated result for Cascode current mirror

4. Triple Cascode Current Mirror

Output impedance can be further increased by adding one more stage to double cascode configuration. [1] Triple cascode configuration is shown in fig. 7.

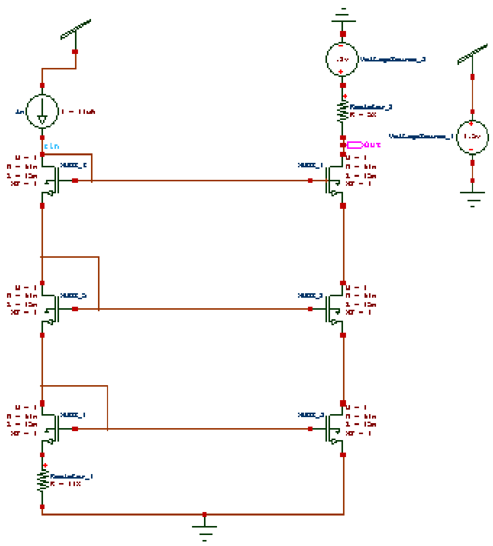

Fig 7: Triple Cascode current mirror circuit

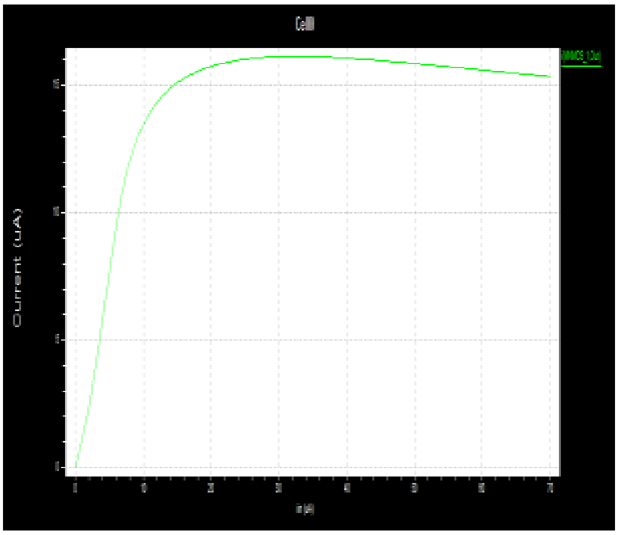

Fig 8: Simulated result for Triple Cascode current mirror

5. Wilson current mirror: Increased output resistance and increased effective open circuit voltage can be obtained by a cascode multiple current mirror configurations. An alternative configuration is the Wilson current source, which utilizes negative feedback in configuration. Such a configuration has been found to have improved output compliance [9], which is the voltage range at the output node over which the current source continues to function as a proper current source. However, with the Wilson current mirror, the accuracy is reduced. The cascoded current mirror has better such accuracy, but reduced compliance [10].

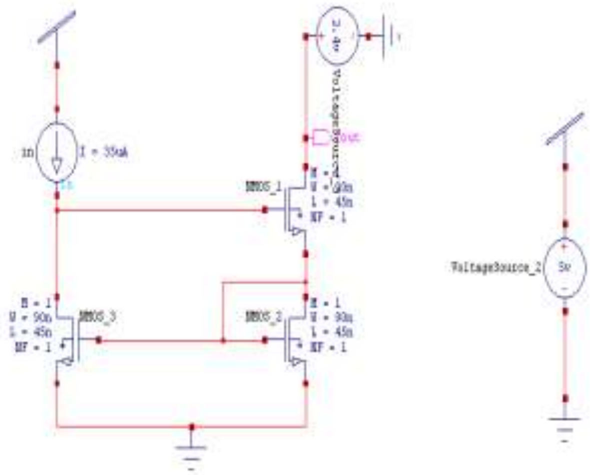

Fig 9: Wilson current mirror circuit

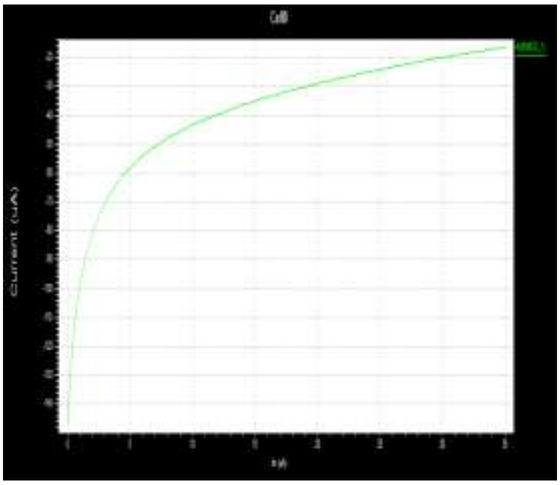

Fig 10: Simulation Results of Wilson Current Mirror

6. Low Voltage current mirror : One of the most fundamental building blocks of analog integrated circuit is the Low Voltage current mirror . This circuit combines a shunt input feedback and a regulated cascode output stage to achieve low input resistance and very high output resistance. It can be used as a high-precision current mirror in analog and mixed signal circuits with a power supply close to a transistor's threshold voltage. The output impedance

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determines the variation of the mirrored current when the voltage applied at input is varied. High output impedance implies less current variation with applied voltage and hence more stable current source Voltage .

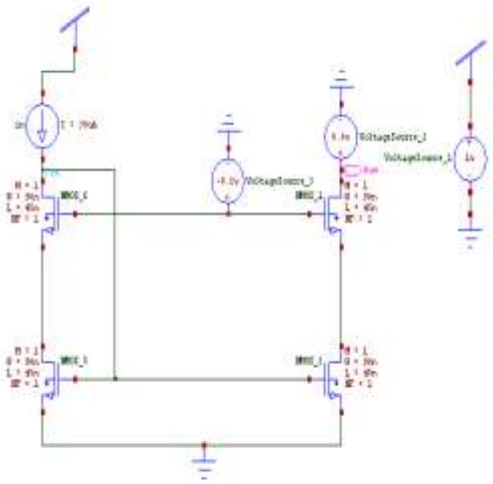

Fig 11: low voltage current mirror circuit

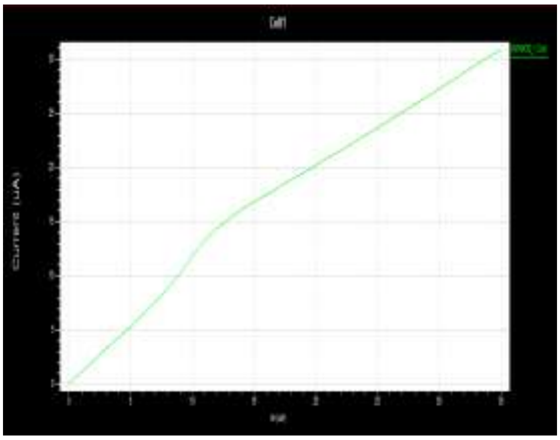

Fig 12: Simulation Results of low voltage Current Mirror

3. SIMULATED RESULTS

The table 1 shows the simulated and calculated parameters of the different current mirrors.

From the table it is clear that performance wise the Low voltage current mirror is better than the other current mirrors because the power dissipation is very small and other parameters are also high as compare to others.

Table 1: Comparison of different current mirror

Parameter	Simple CM	Regulated CM	Cascode CM	Triple Cascode CM	Wilson CM	Low Voltage CM
Average Power	87uw	25.8uw	21uw	52uw	87uw	17uw
Slew rate	0.5u	7.19u	1.9u	0.7u	2.4u	7.6u
Trans conductance	129u	150u	168u	434u	639u	1385u
Supply voltage	5v	1.2v	1.8v	1.2v	5v	1v
Simulation technology	45nm	45nm	45nm	45nm	45nm	45nm
Number of transistors	2	3	4	6	3	4

4. CONCLUSION

Here we are analyzed and simulated different current mirrors using 45nm technology, reducing the technology itself enhancing the performance parameters of a circuit. Here have compared the simple CM, Regulated CM, Cascode CM, Triple Cascode CM, Wilson CM and Low voltage CM. by analyzing all of them it is concluded that the Low voltage current mirror has better performance than others. Because of its small power dissipation and high transconductance. Wilson current mirror can also be used as a low biasing circuit.

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