Optimal High-Performance CMOS Self Cascode Current Mirror

Ancy Hassan
ancymcet@gmail.com
Musaliar College of Engineering and Technology,
Pathanamthitta, Kerala

Nishi G Namboothiri
nishisudeep@gmail.com
Musaliar College of Engineering and Technology,
Pathanamthitta, Kerala

ABSTRACT

In this paper, the current mirror presented, having low voltage and mixed mode structure has been proposed. The performance of self cascode MOSFET current mirror is optimized with high output impedance and can operate at 1 V or below. This review paper presents a comparative performance study of self CASCODE current mirror with other current mirrors. To meet the need of a present era of low power portable electronic equipment, many voltage design techniques have been developed. This led to analog designers to look for innovative design technique such as self cascode CMOS current mirror. In this paper investigate the merits and demerits of various current mirror circuit. For this first, develop basic current mirror and then cascode current mirror, Wilson current mirror and finally current mirror based selfcascode current mirror. The result is analyzed through spice simulation.

Keywords: CMOS, Self Cascode Current Mirror, MOSFET.

1. INTRODUCTION

To meet the needs of the present era of low power portable electronic equipment many low voltage design techniques have been developed. This led to the analog designers to look for innovative design technique like self cascode CMOS current mirror. In this paper, we have investigated the merits and demerits of various current mirror configuration.

For this, we designed the basic current mirror first then improved our results by using a various configuration like cascode current mirror, Wilson current mirror, and finally, the current mirror based on self cascode CMOS and analyzed the result through spice simulation. In this paper, the current mirror presented having low voltage and mixed mode structure has been proposed. The performance of self cascode MOSFET current mirror is optimized with high output impedance and can operate at 1 v or below 1v. This review paper presents a comparative performance study of self cascode current mirror with other current mirrors.

1.1 BASIC MOSFET CURRENT MIRROR

The basic current mirror is implemented using transistor MOSFET. Transistor M1 is operated in saturation mode or active mode and so as M2. In this setup output current is directly related to reference current.
For a current mirror neglecting the channel length modulation

\[ I_{out} = \frac{1}{2} \mu_n C_{ox} \frac{W}{L} \left( V_{gs} - V_{th} \right)^2 \]

\[ I_{ref} = \frac{1}{2} \mu_n C_{ox} \frac{W}{L} \left( V_{gs} - V_{th} \right) \]

Limitations:
- Current gain is poor and output current have channel length modulation effects.
- Output resistance is finite

1.2 CASCODE CURRENT MIRROR

The idea of cascode structure is employed to increase the output resistance and the implementation requires NMOS technology. It is used to avoid channel length modulation in basic current mirror circuit. The circuit features a wide output voltage swing and requires an input voltage of approximately one diode drop plus a saturation voltage. By maintaining the input transistor in saturation output current will track the input current regardless the improved ambient temperature.

MERITS
- Cascode current mirror eliminate the effect of channel length modulation effect by keeping \( v_{ds1} = v_{ds2} \).
- Improve output resistance.

DEMERITS
- Less accurate
- Current becomes constant for quite large value of \( V_{ds} \).
- Body effect is also present which disturbs the output.

1.3 WILSON CURRENT MIRROR

A Wilson current mirror or Wilson current source is a circuit configuration designed to provide a constant current. This circuit has the advantage of virtually eliminating the current mismatch of the conventional current mirror thereby ensuring that the output current \( I_{out} \) is almost equal to the reference or input current \( I_{Ref} \) thus eliminating the drawbacks of cascode structure.

MERITS
- Curve is much flatter than basic current mirror.
- Output resistance is much higher than the cascode current mirror this is caused by two positive feedback.

DEMERITS
- Current become constant for a large value of \( v_{ds} \).

1.4 LOW VOLTAGE SELF CASCODE CURRENT MIRROR

A self cascode current mirror is proposed that required a low bias voltage of the order of ± 1.0V [9, 10]. The selection criterion for \( I_3 \) is to ensure lower \( V_{in} \). \( I_2 \) is selected to ensure ON condition for \( M_6 \). The small signal transfer analysis of this circuit at 20 \( \mu A \) gave the current gain, i.e. \( I_{out}/I_{in} = 1 \), and output resistance as 10 M\( \Omega \). The power dissipation for this is high. This approach of increasing the W/L aspect ratios works effectively at low bias voltage \( V_{in} \) of 1v making it quite attractive for biasing analog circuits requiring high output resistance and gain. Hence they can extensively be used where power supply requirements are not the constraint.
MERITS

- High performance since output current is constant for large value of $v_{ds}$.
- High output impedance.

DEMERTS

- Power dissipation is high

2. COMPARISON OF DIFFERENT CURRENT MIRRORS

A comparison between different current mirror circuit is studied by simulation and is given in the table below:

<table>
<thead>
<tr>
<th>Current mirror</th>
<th>Stability</th>
<th>Output resistance</th>
<th>Minimum output voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic current mirror</td>
<td>Poor</td>
<td>126k</td>
<td>0.254</td>
</tr>
<tr>
<td>Cascode current mirror</td>
<td>Good</td>
<td>1.07M</td>
<td>1.22</td>
</tr>
<tr>
<td>Wilson current mirror</td>
<td>Better</td>
<td>2M</td>
<td>1.27</td>
</tr>
<tr>
<td>Self cascode current mirror</td>
<td>Excellent</td>
<td>10M</td>
<td>0.26</td>
</tr>
</tbody>
</table>

3. RESULTS AND DISCUSSION

Comparison of current mirrors by simulation of the circuit using LT spice model.

3.1 BASIC CURRENT MIRROR

![Simulation Results in Basic Current Mirror](image1)

![Simulation Results in Basic Current Mirror](image2)
3.2 CASCODE CURRENT MIRROR

SIMULATION RESULT OF CASCODE CURRENT MIRROR

3.3 WILSON CURRENT MIRROR
SIMULATION RESULT OF WILSON CURRENT MIRROR

4. CONCLUSION

Current mirrors are one of the most common building blocks both in analog and mixed-mode signal VLSI circuits. A current mirror is an element with at least three terminals. The common terminal is connected to power supply or ground and the input current source is connected to the input terminal. Ideally, the output current is equal to the input current is multiplied by the desired current gain. If the gain is unity input current is equal to output current name is a current mirror. This paper presents the description of simple, cascode, Wilson current mirror and give a brief description of low voltage cascode current mirror. Finally the current mirror circuits are described is compared in terms of voltage and current and output impedance using LT spice simulation tool.

5. REFERENCES