

Design and analysis of Basic and Wilson current mirror in 180nm CMOS technology

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Abstract

This report documents the outcomes of a research migration project conducted by FOSSEE, wherein the electronic circuits and simulations of a research paper titled *Design and Analysis of Basic and Wilson Current Mirror Current Mirrors in 45nm and 180nm CMOS Technology* were successfully replicated using the open-source EDA tool **eSim**, utilizing the default eSim library models under **180nm technology**. The original simulations presented in the paper were performed in Cadence Virtuoso.

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1 Introduction and Theory

1.1 Introduction

Current mirrors play a crucial role in the design of modern integrated circuits, where they are used to maintain precise current matching and biasing in various analog and mixed signal circuits. They serve as essential building blocks for applications like voltage references, operational amplifiers, and analog-to-digital converters. Two commonly used current mirror configurations are the basic current mirror and the wilson current mirror.

1.2 Theory

A basic current mirror consists of two identical NMOS or PMOS transistors. The drain of one of the mosfets sets the reference current I_{ref} and the other mirrors this current.

$$I_{ref} = \frac{1}{2}k'_{n1}\left(\frac{W}{L}\right)_1(V_{GS1} - V_{th})^2, \quad (1)$$

$$I_{out} = \frac{1}{2}k'_{n2}\left(\frac{W}{L}\right)_2(V_{GS2} - V_{th})^2. \quad (2)$$

$$\frac{I_{out}}{I_{ref}} = \frac{(W/L)_2}{(W/L)_1} \quad (3)$$

Assuming the transistors are perfectly matched and operating in the saturation region, reference current flowing through M1 is mirrored in M2, producing the output current I_{out} . While simple in design, this configuration suffers from:

- Finite output impedance due to the Early effect, limiting its performance as an ideal current source.
- Poor current matching at higher output voltages.

The Wilson current mirror is an improved version of the basic current mirror. It provides higher output impedance and better accuracy in current mirroring, making it suitable for precision applications. In the MOSFET-based Wilson Current Mirror, three transistors are employed: two act as the reference and output current sources, while the third improves output impedance and reduces current mismatch error.

2 Circuit Diagrams

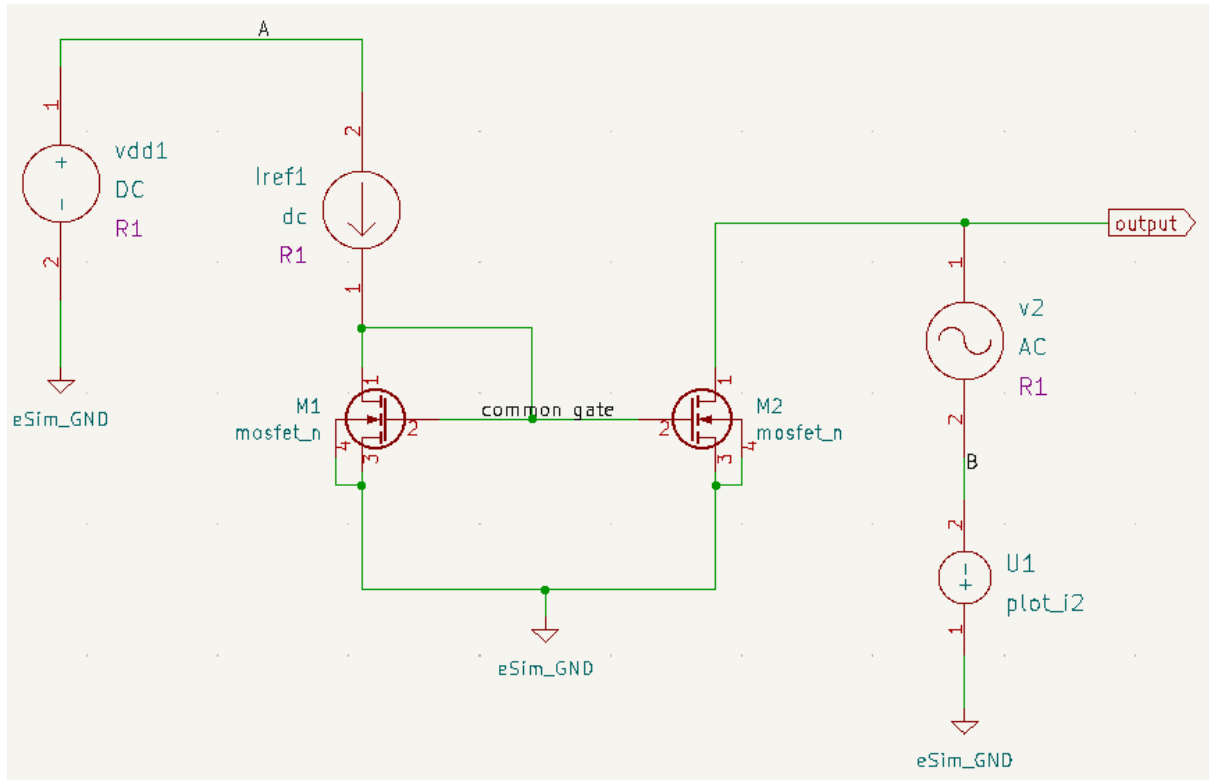


Figure 1: kiCad schematics of Basic current mirror

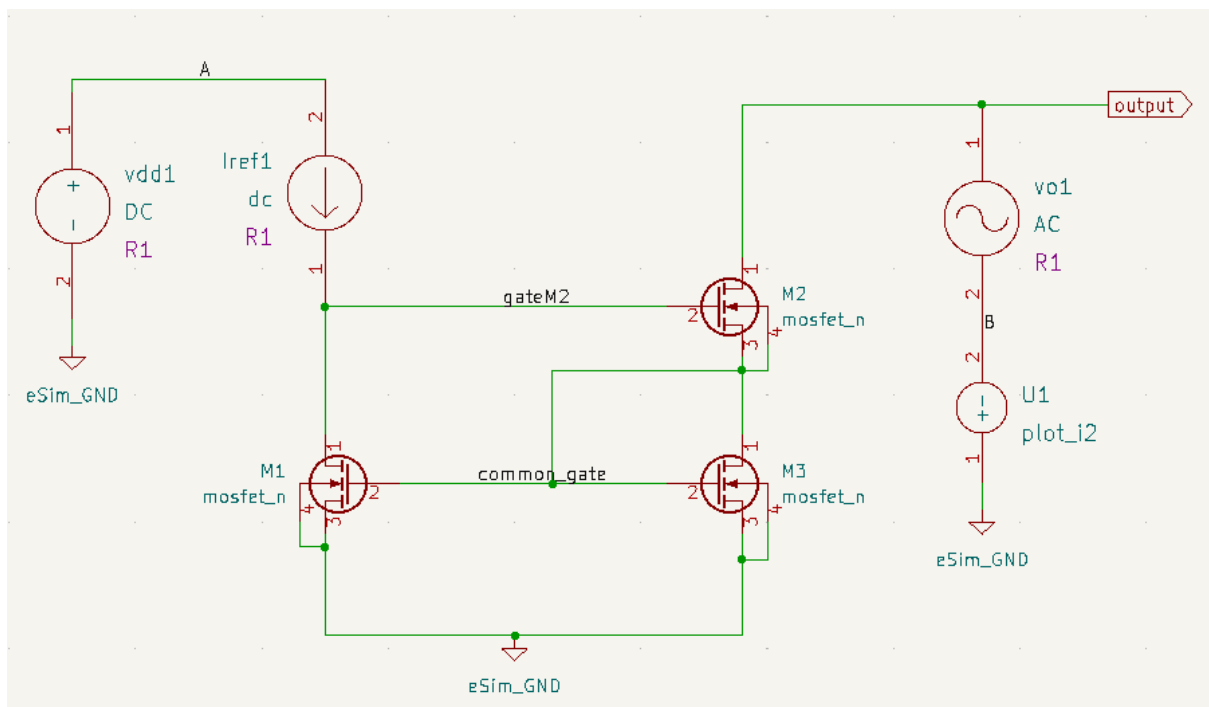


Figure 2: kiCad schematics of Wilson current mirror

3 Output Plots

Plots of DC, AC analysis and output impedance in ngspice

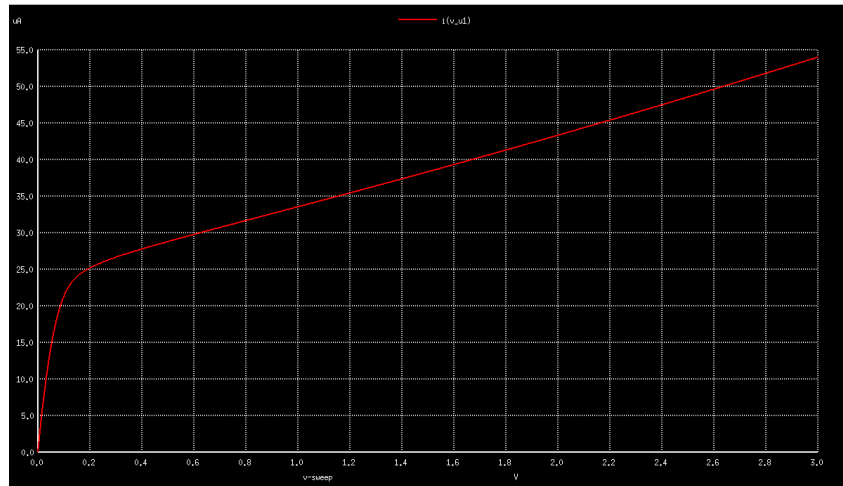


Figure 3: DC Analysis of Basic current Mirror

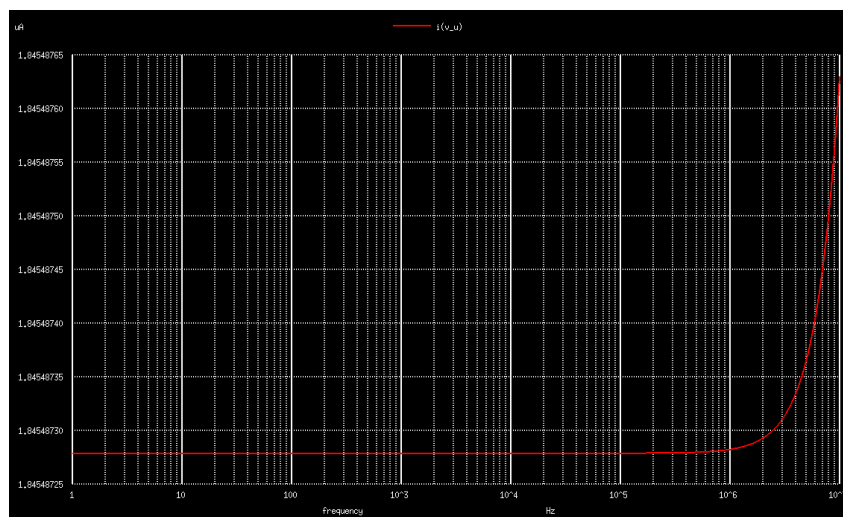


Figure 4: AC Analysis of Basic current Mirror

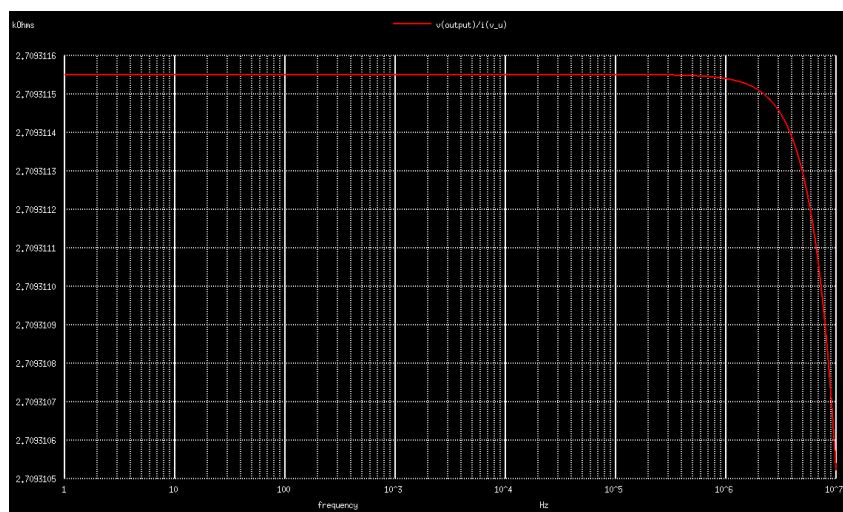


Figure 5: AC Analysis of Basic current Mirror

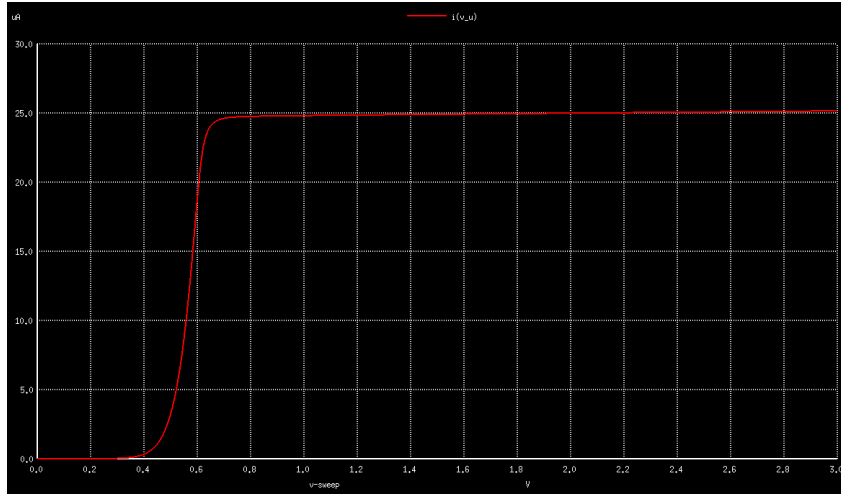


Figure 6: DC Analysis of Wilson current Mirror

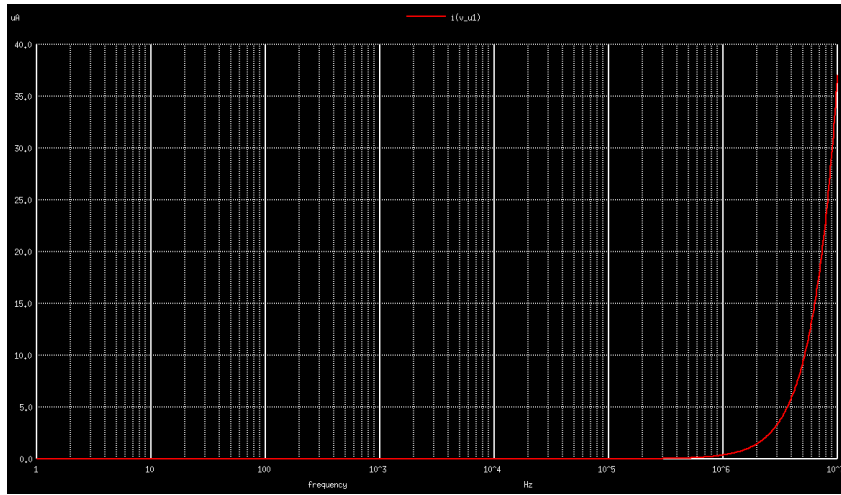


Figure 7: AC Analysis of Wilson current Mirror

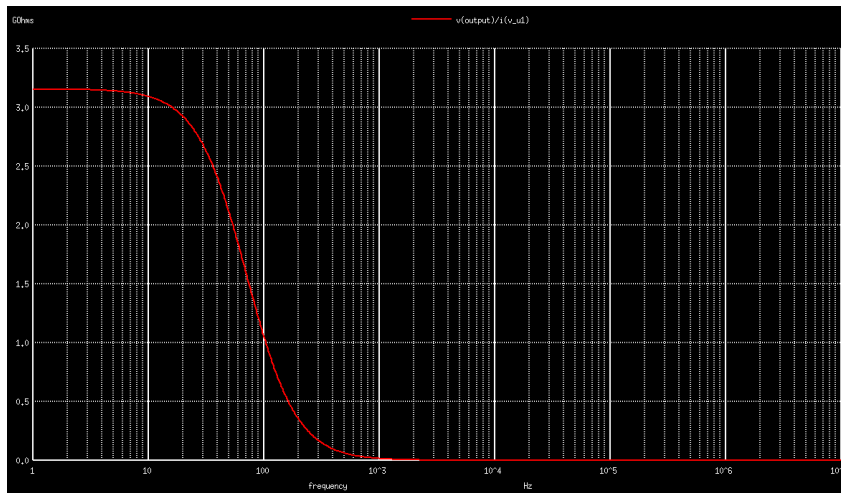


Figure 8: Output impedance of Wilson current Mirror

4 Conclusion

Each of the current mirror topology has been analyzed with DC, AC and Output impedance characteristics under the 180nm CMOS technology. The DC Analysis highlights on the current replication and biasing characteristics under steady-state conditions in the specific technology node. The AC analysis enables the examination of the mirror's dynamic response and performance characteristics under varying input signals and frequencies. Finally, the output impedance characteristics provides insights into it's capacity to maintain stable current replication and voltage regulation against load variations within this particular technology node.

References

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- [2] Adel S Sedra, Kennth C Smith, *MicroElectronic Circuits 7th edn..*