

Online Session 7
Circuit and System

Nov. 2, 2021
Paper ID : CS045

Self-biasing MOS Reference Current Sources Insensitive to Supply Voltage and Temperature

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Gunma University

OUTLINE

- **Research Objective**
- **MOS Drain Current Temperature Characteristics**
- **Gunma University (GU) Reference Current Source**
- **Peaking Current Source (Nagata Current Source)**
- **Widlar Current Source**
- **Conclusion**

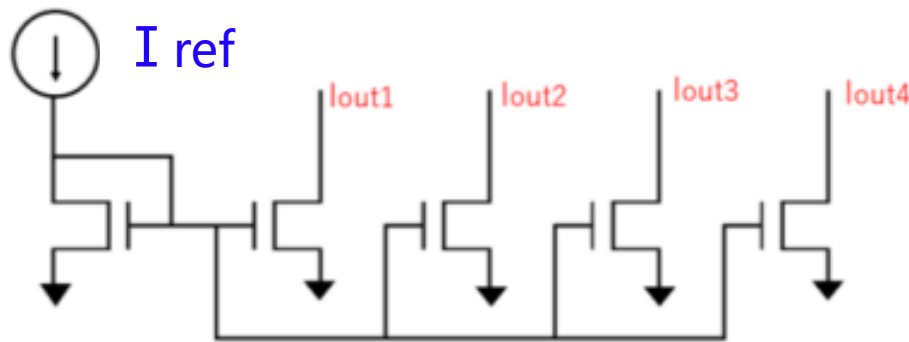
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Research Objective

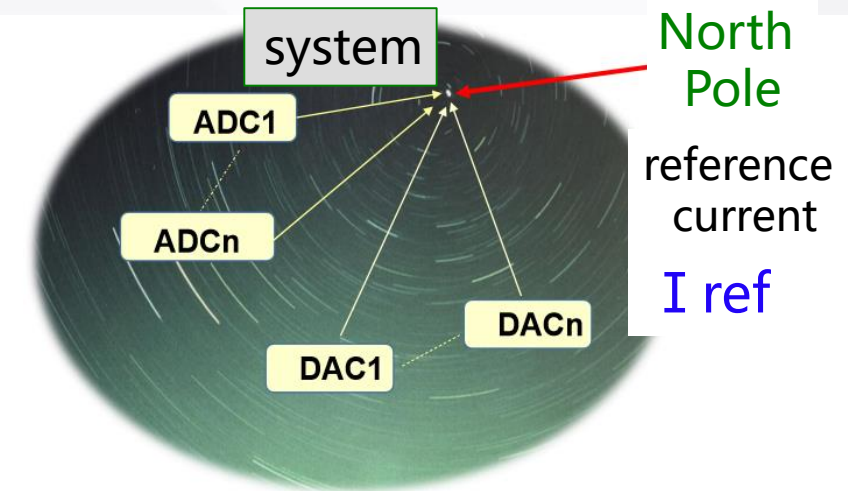
Development of **reference current source** insensitive to temperature and supply voltage with simple CMOS circuit.

Reference current



Three types of MOS reference current sources

- (1) Gunma University (GU) reference current source
- (2) Peaking current source (Nagata current source)
- (3) Widlar current source
with proposed temperature compensation circuit

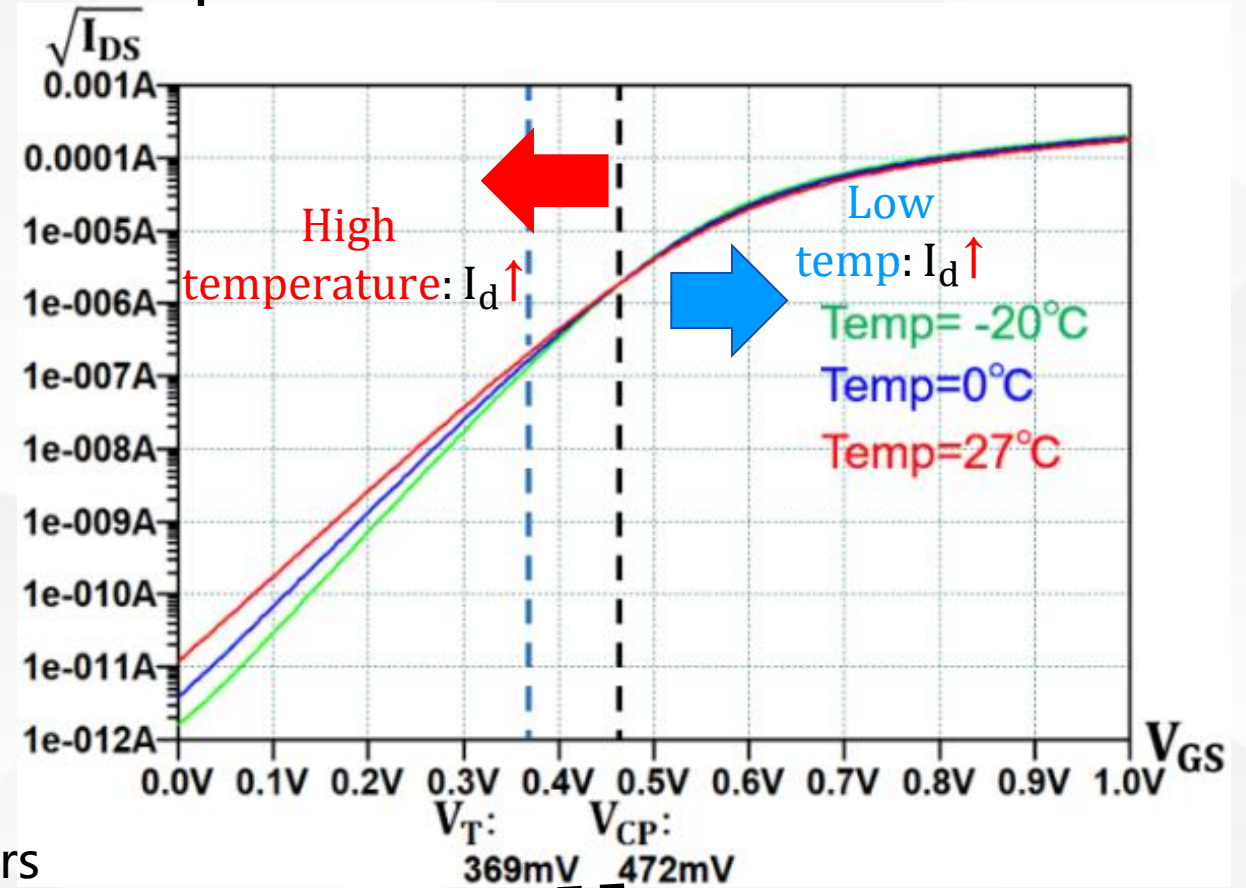
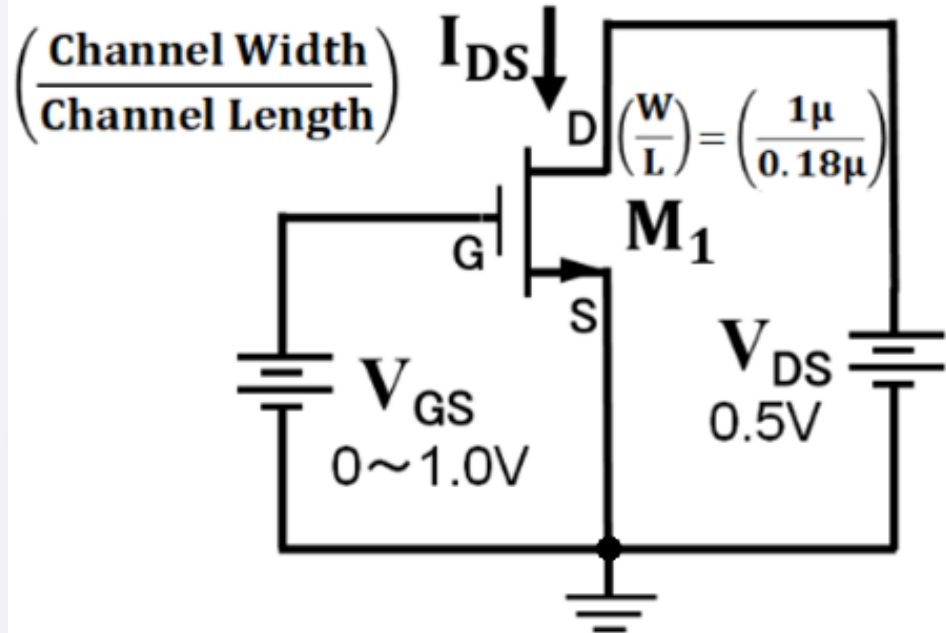


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MOS Drain Current and Gate Voltage

Simulated drain current temperature characteristics



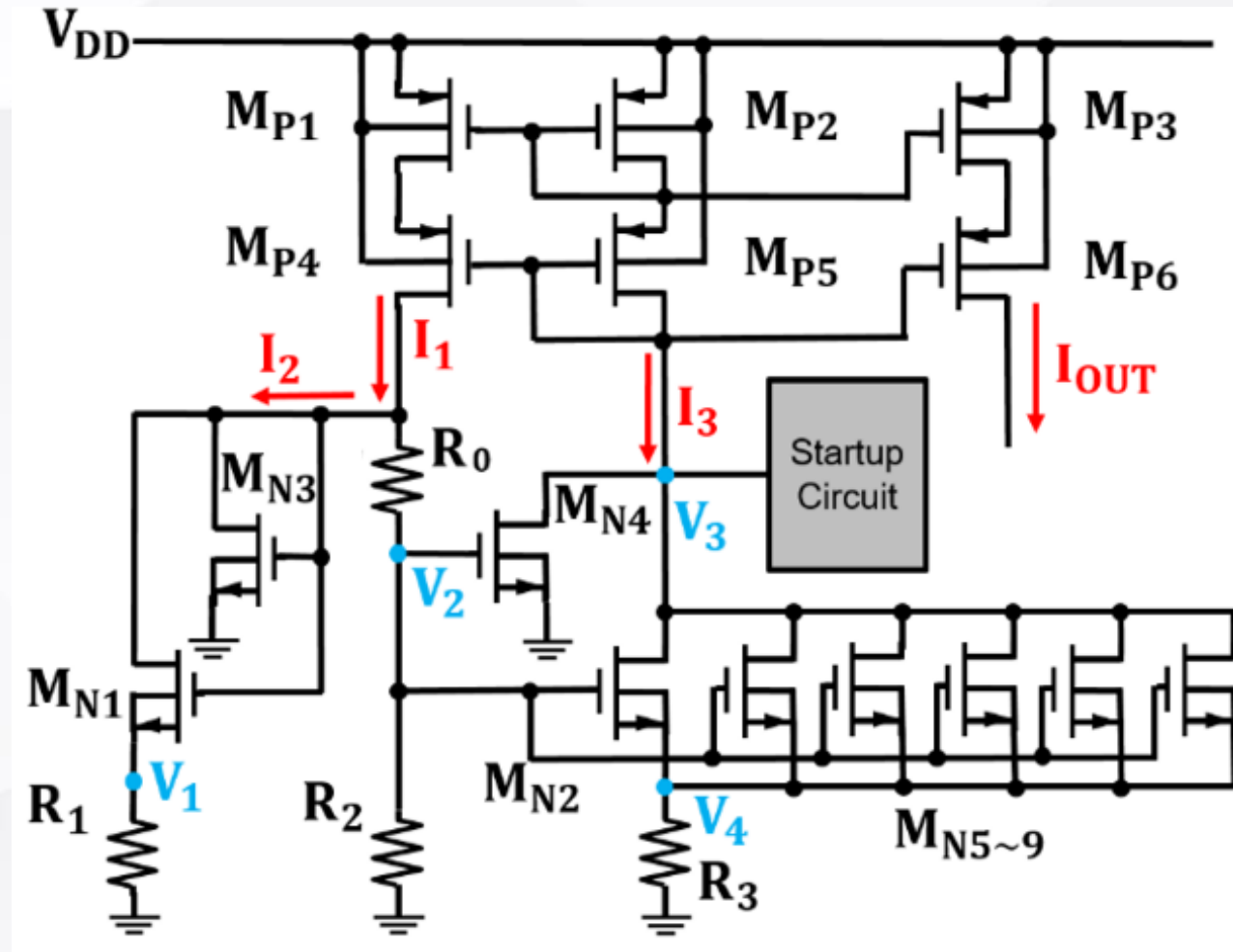
TSMC 0.18 μ m BSIM3v3 CMOS SPICE parameters

At V_{CP} (472mV): Drain current is fixed against temperature change

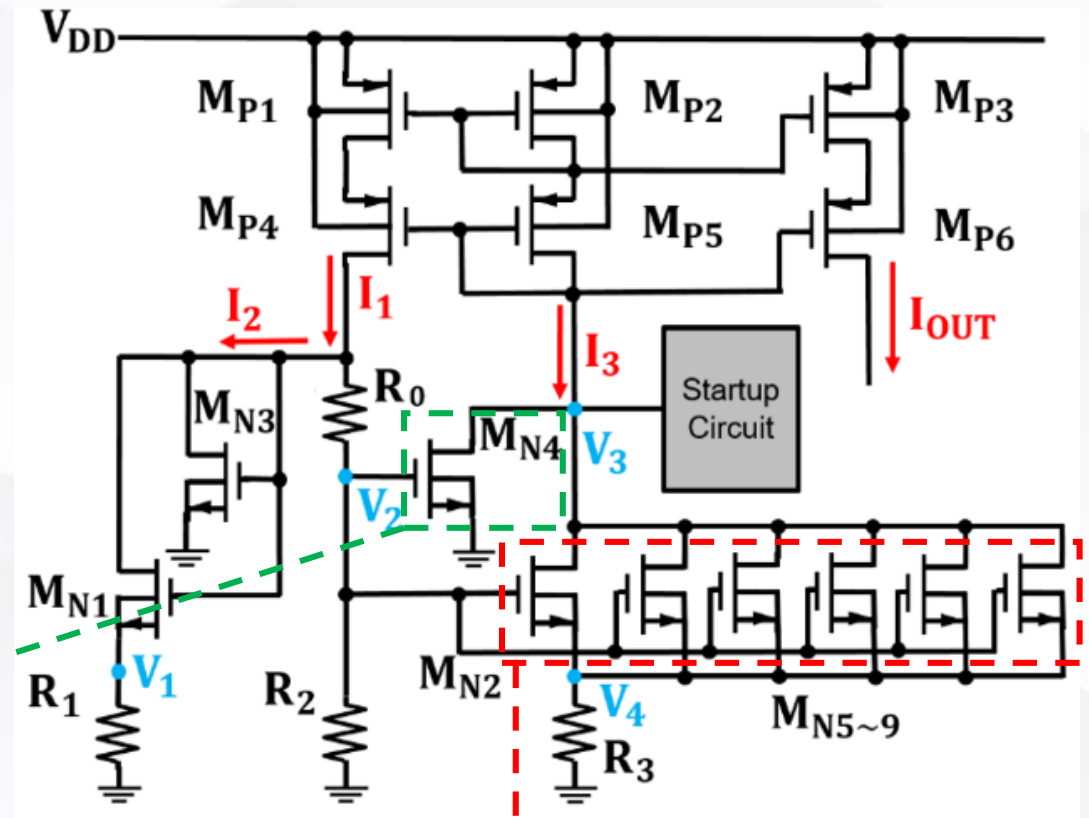
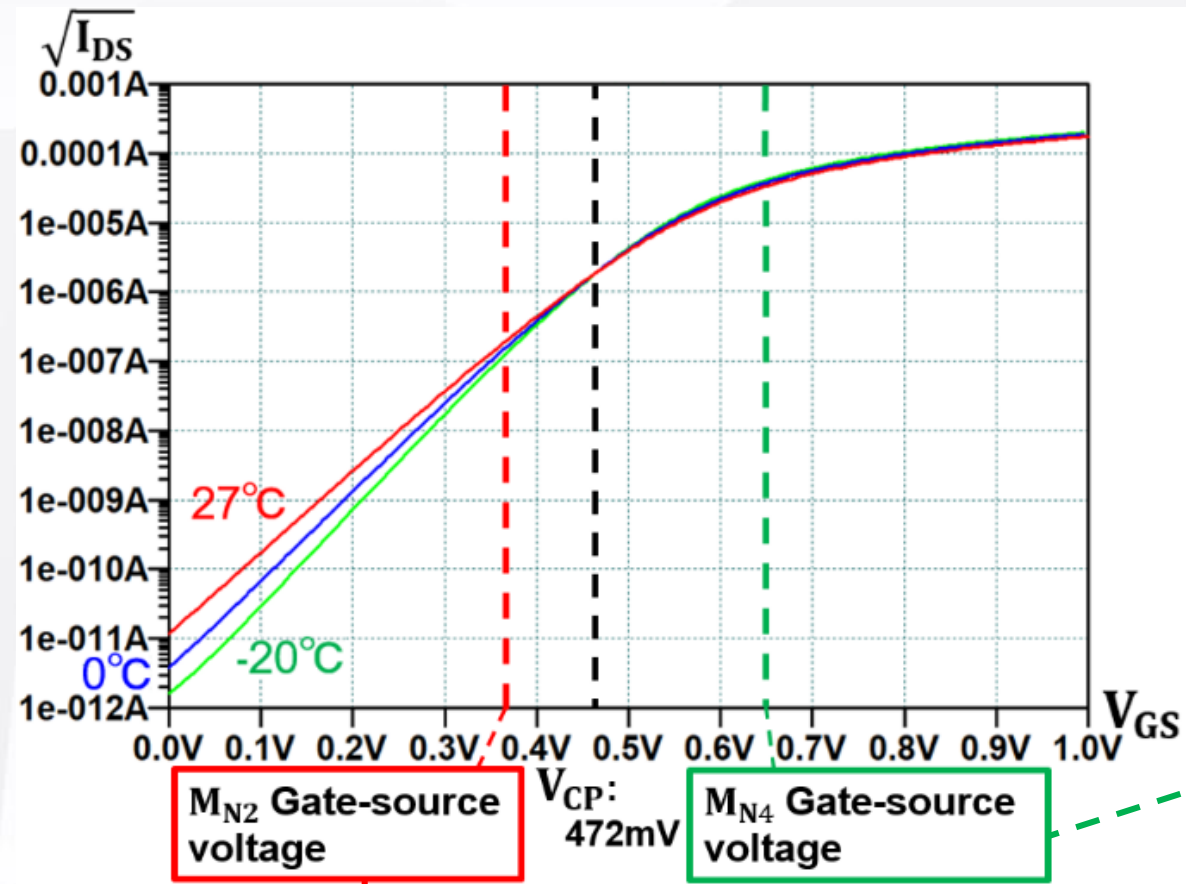
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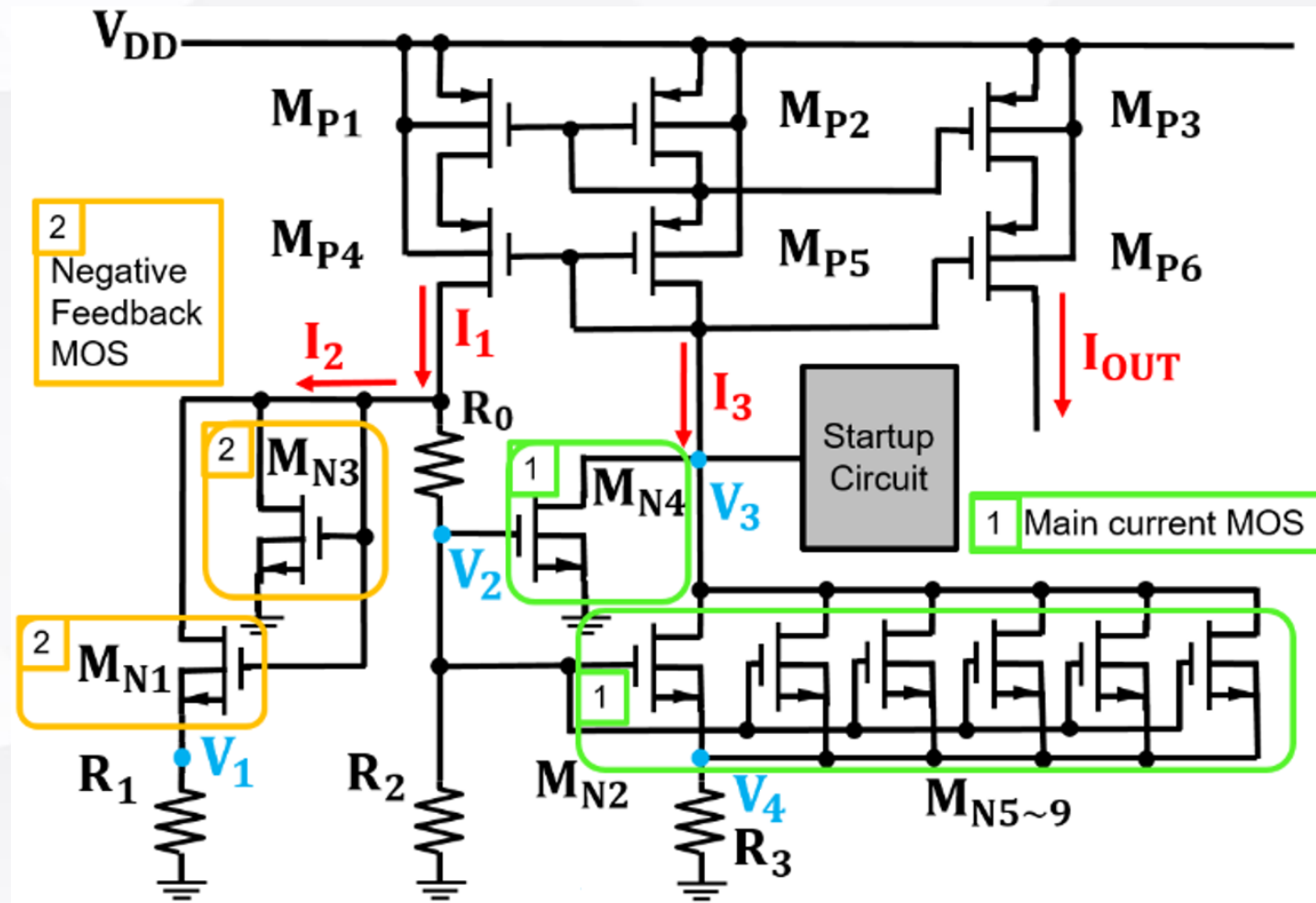
Gunma University (GU) reference current source



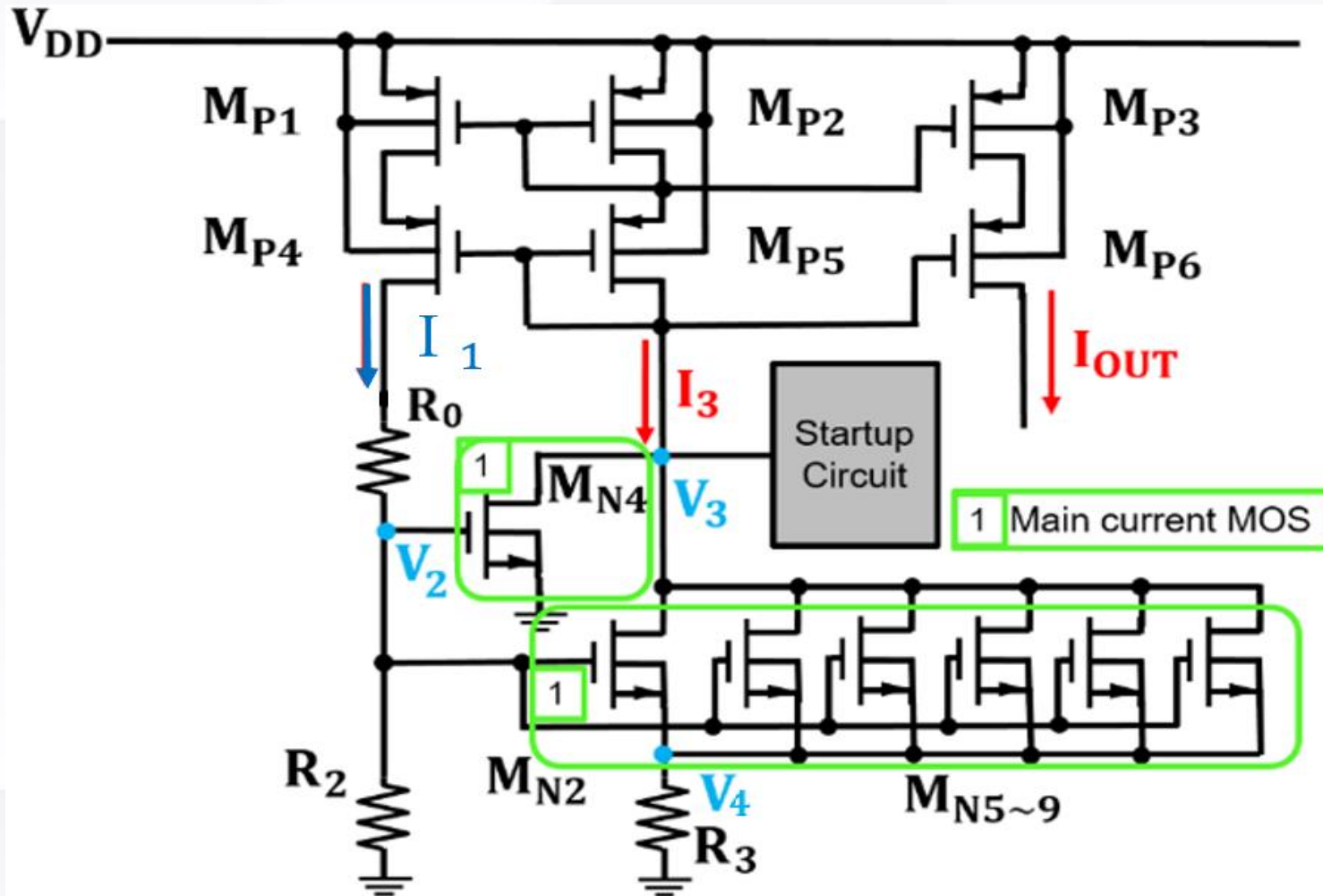
Negative Feedback for Self-Bias



Negative Feedback for Self-Bias



Self-Bias Problem



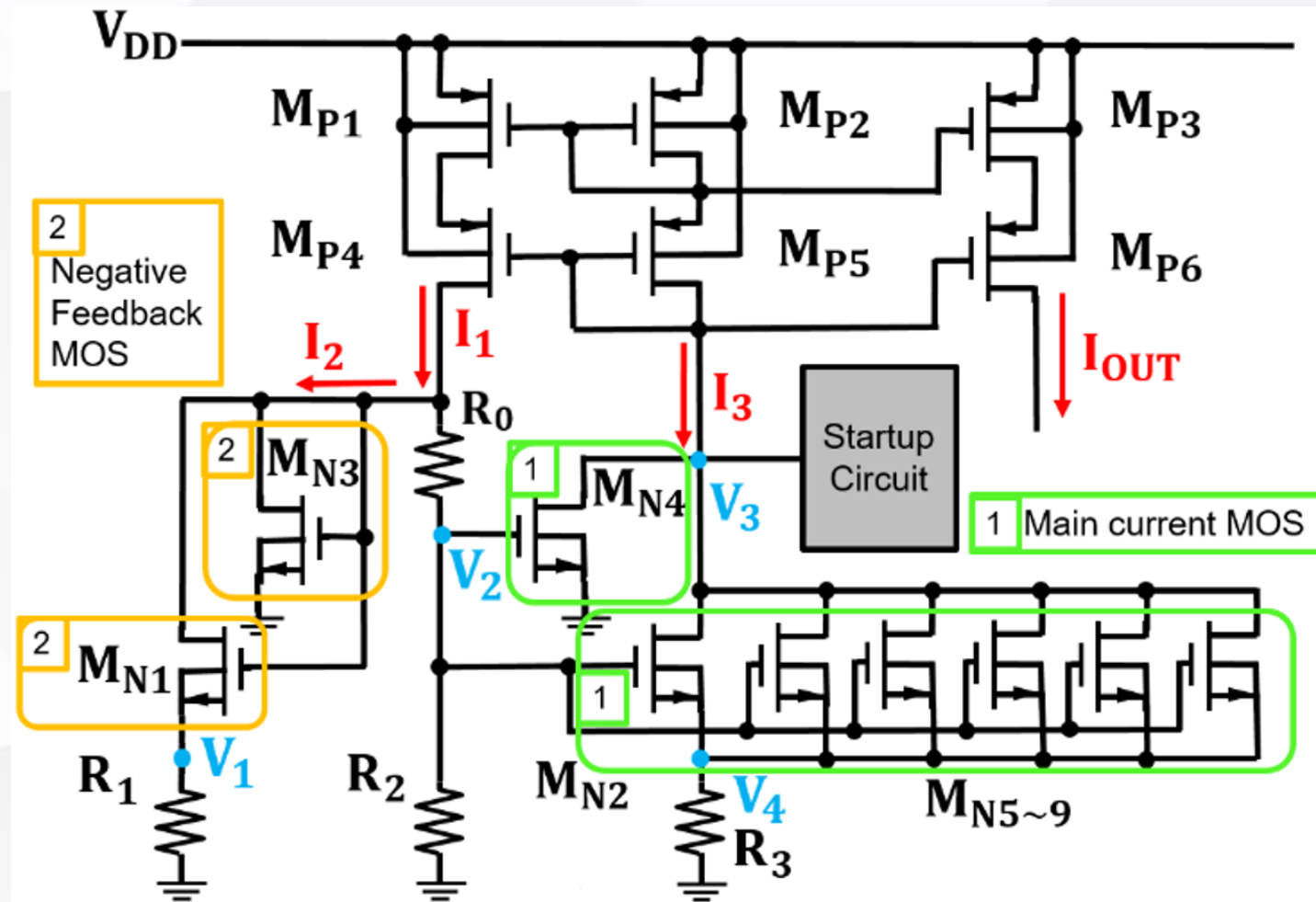
- I_1 increase
- I_3 increase
- I_1 increase
- I_3 increase

⋮



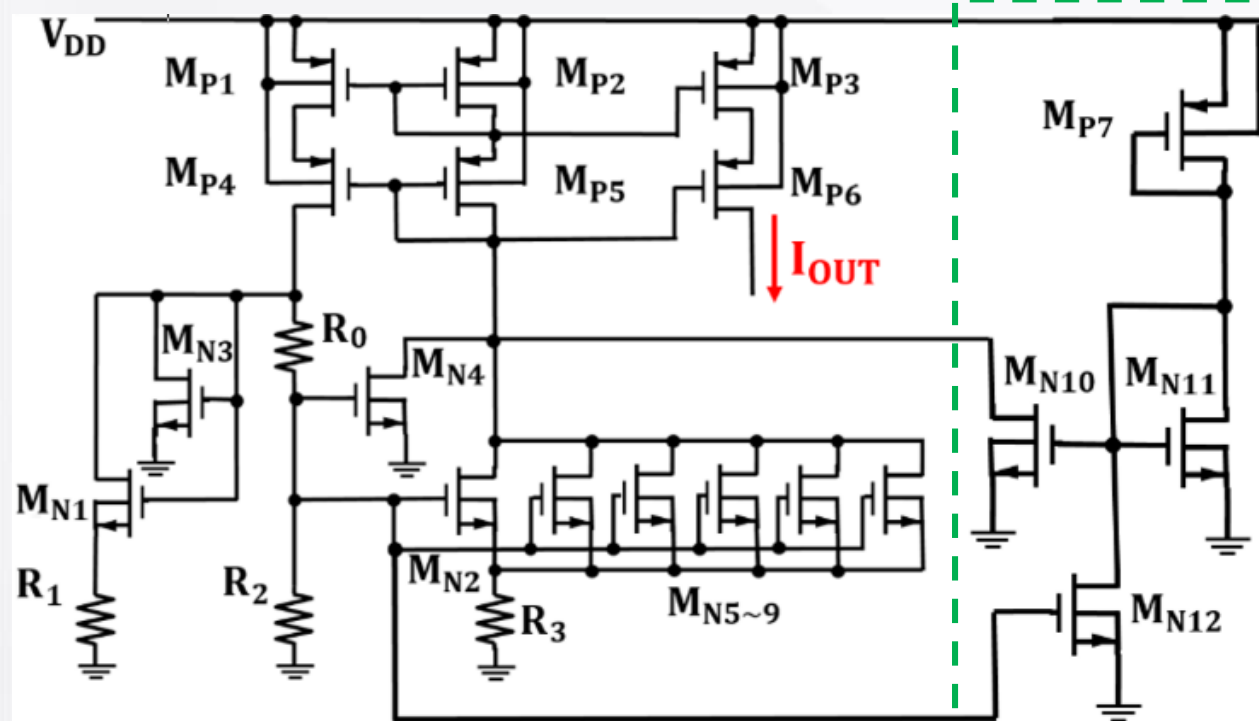
Positive Feedback !

Negative Feedback for Self-Bias

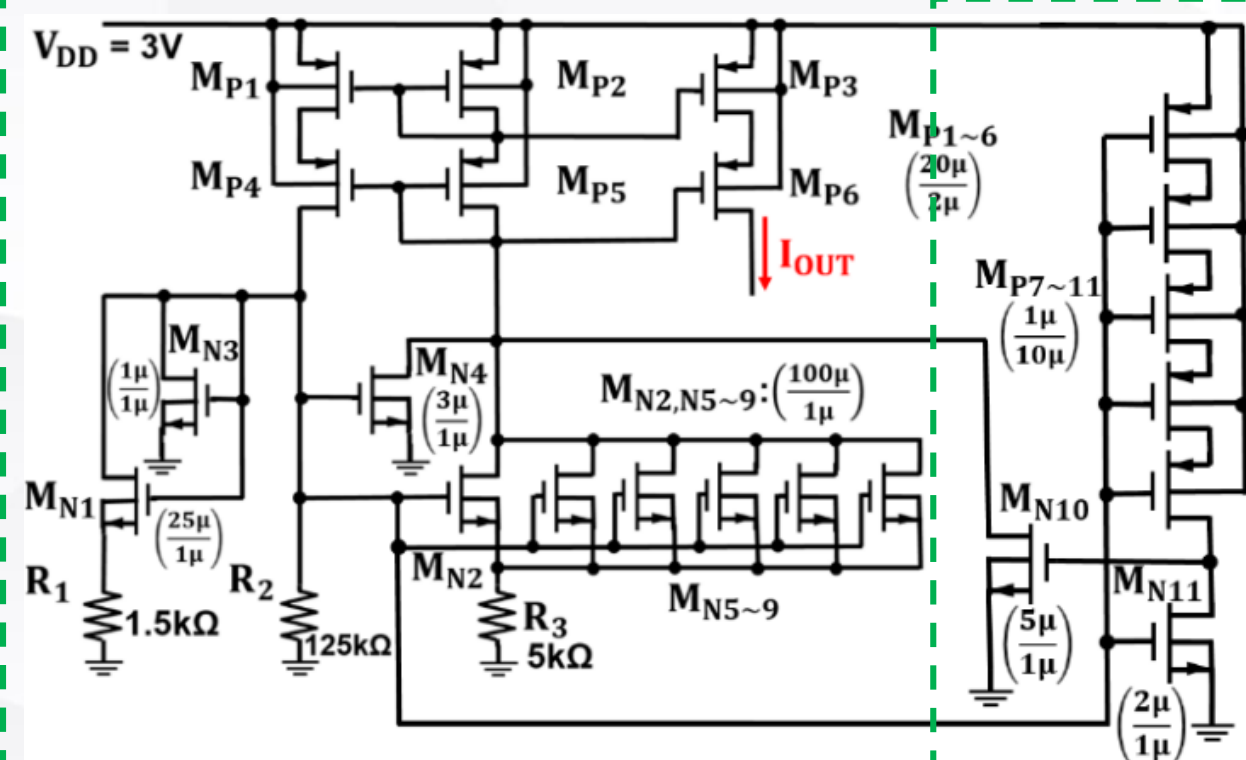


Improvement of Startup Circuit

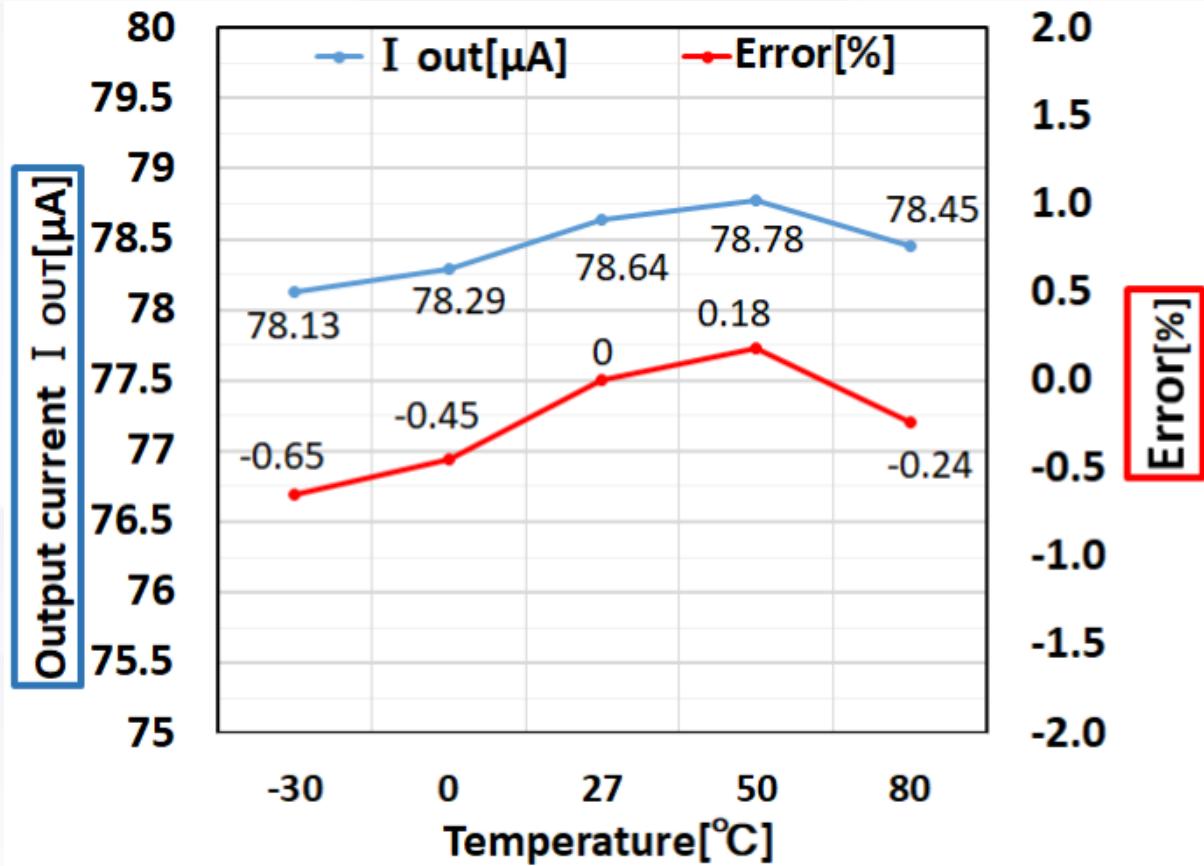
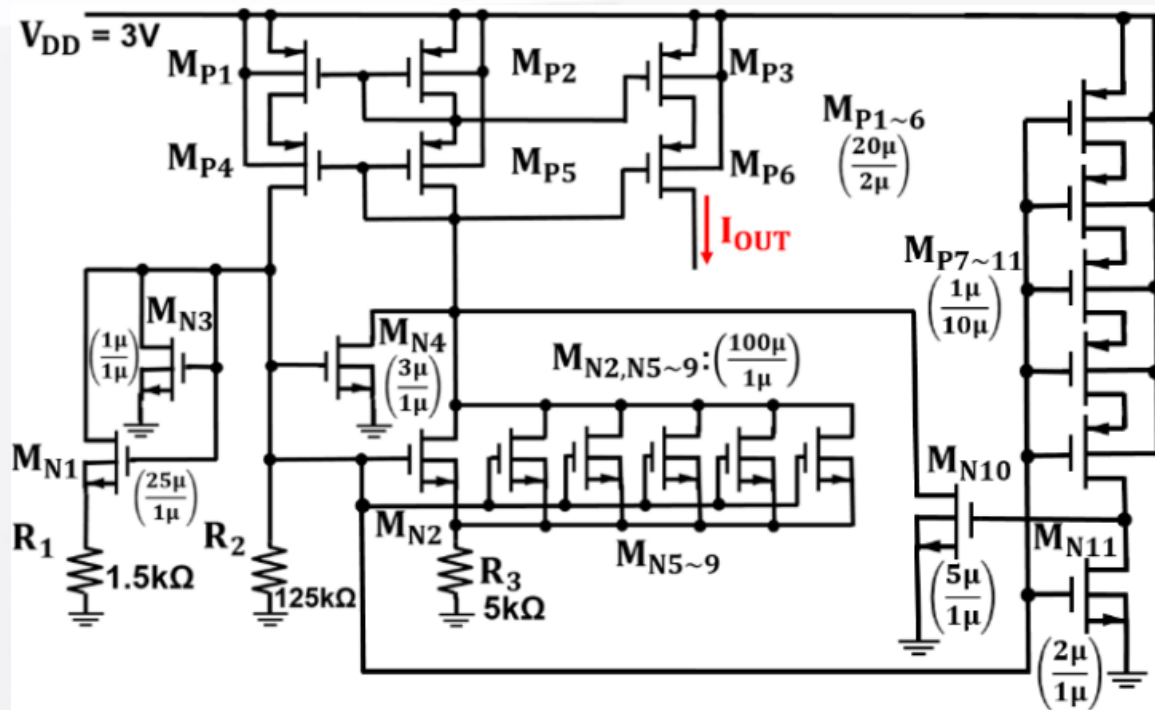
Previous



Improved



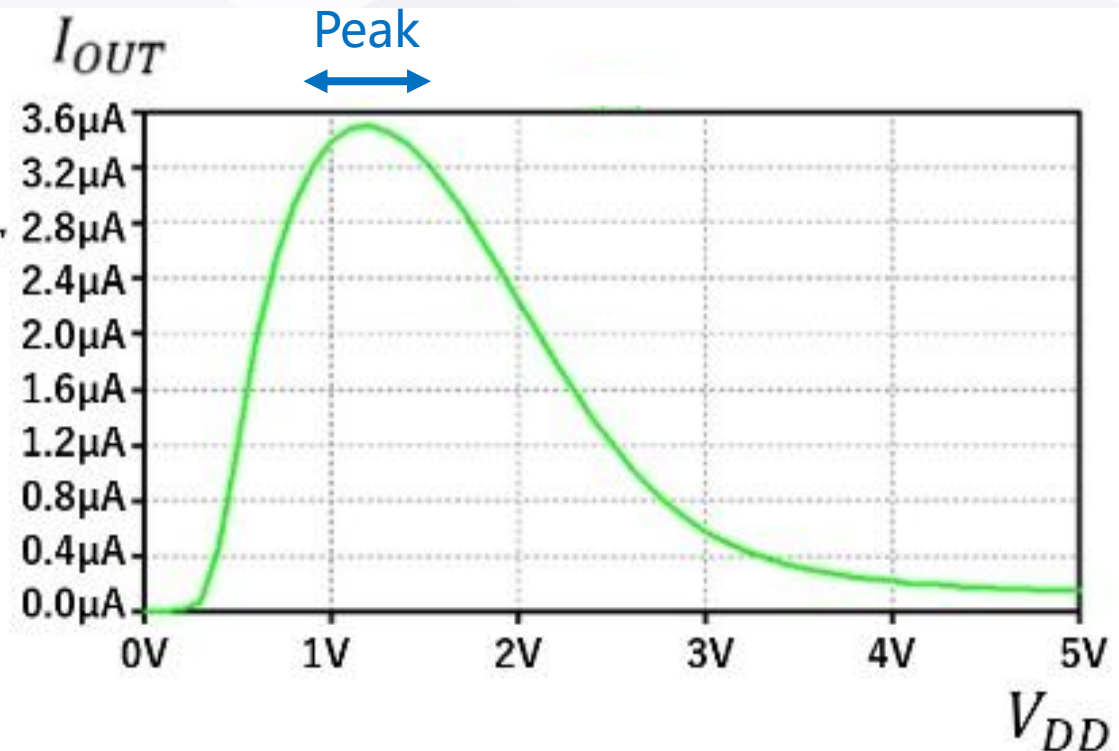
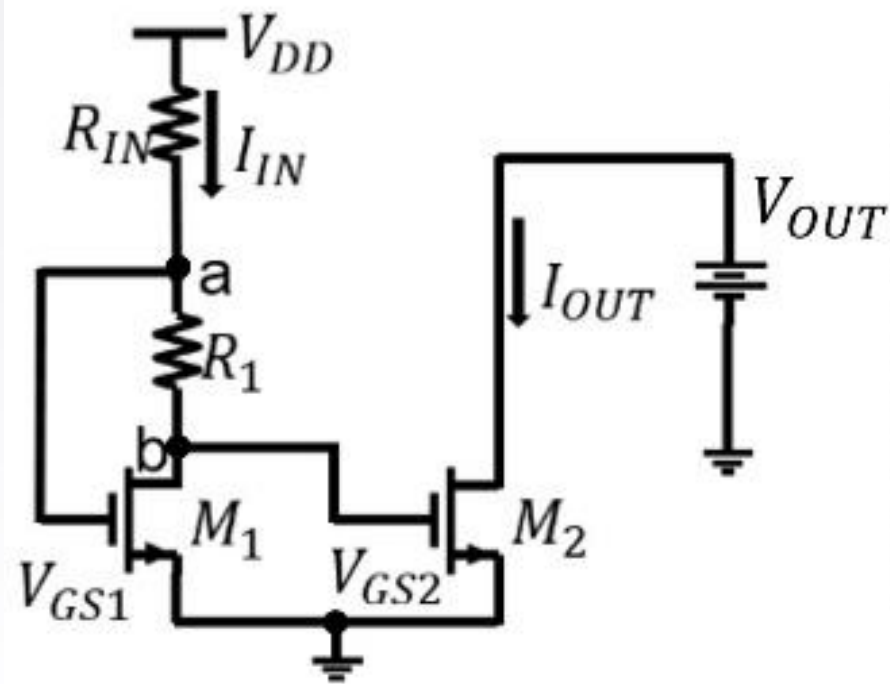
Output Current I_{OUT}



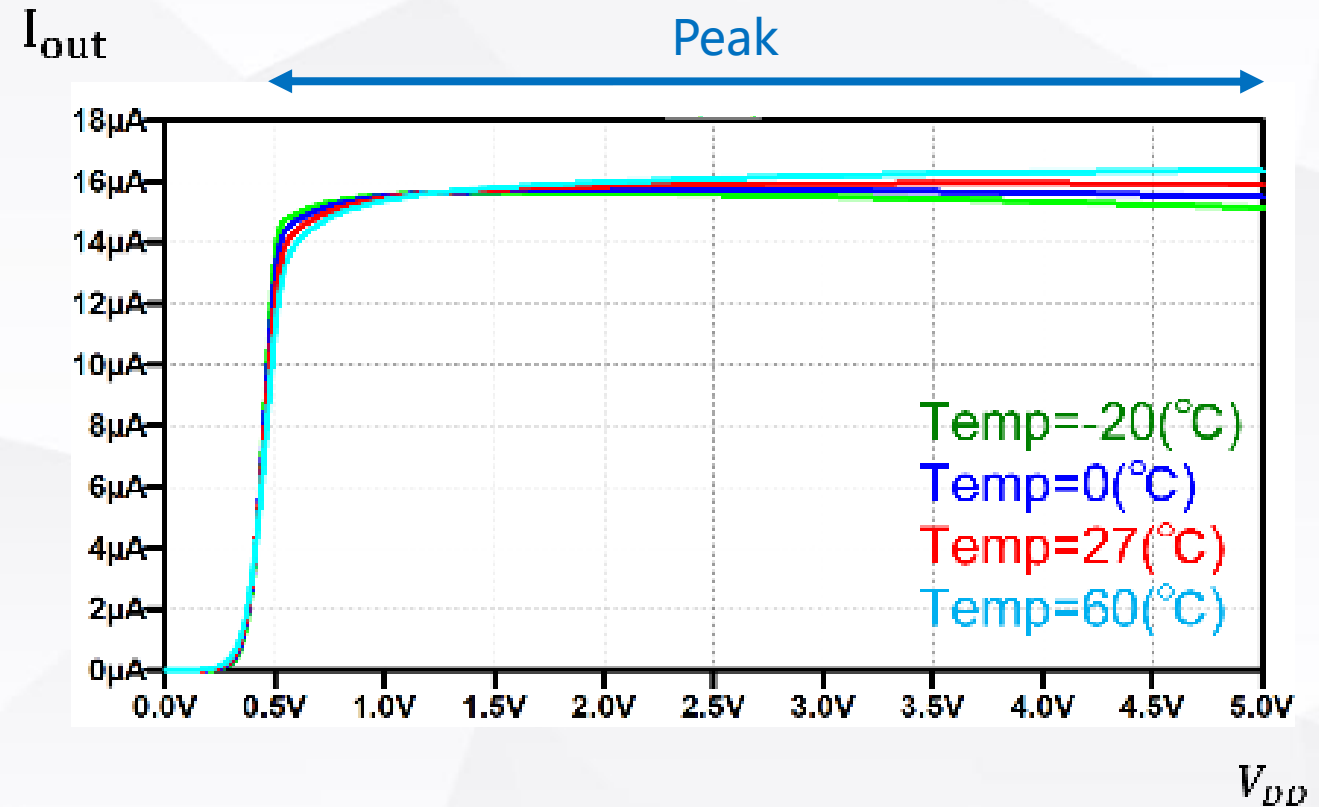
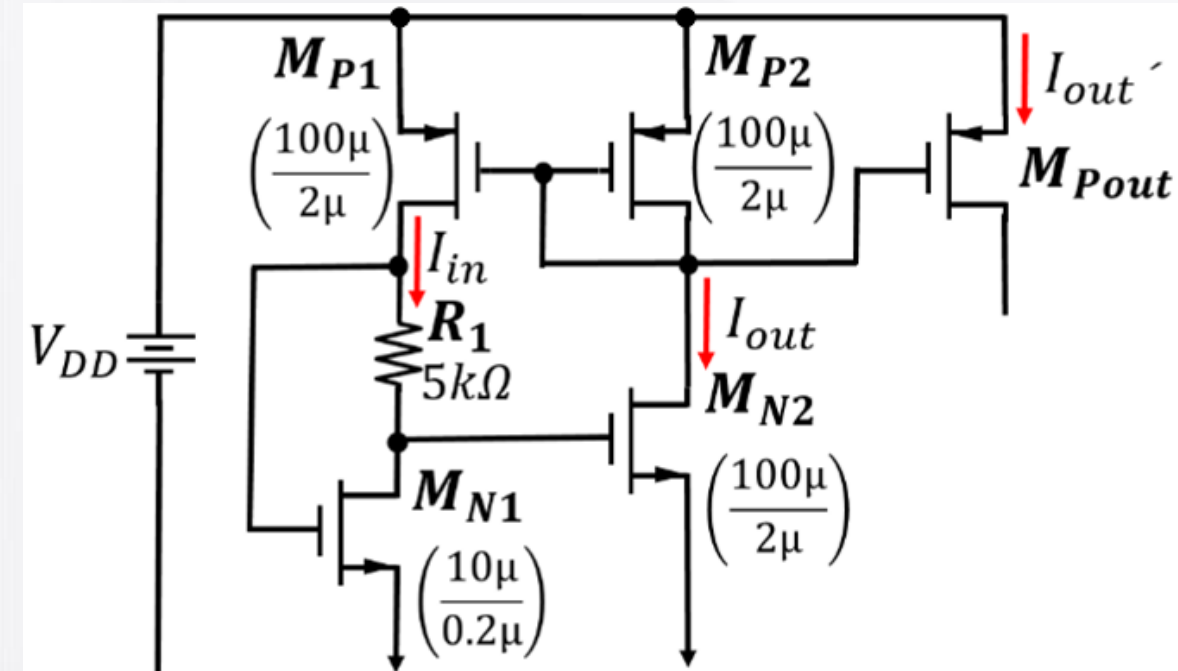
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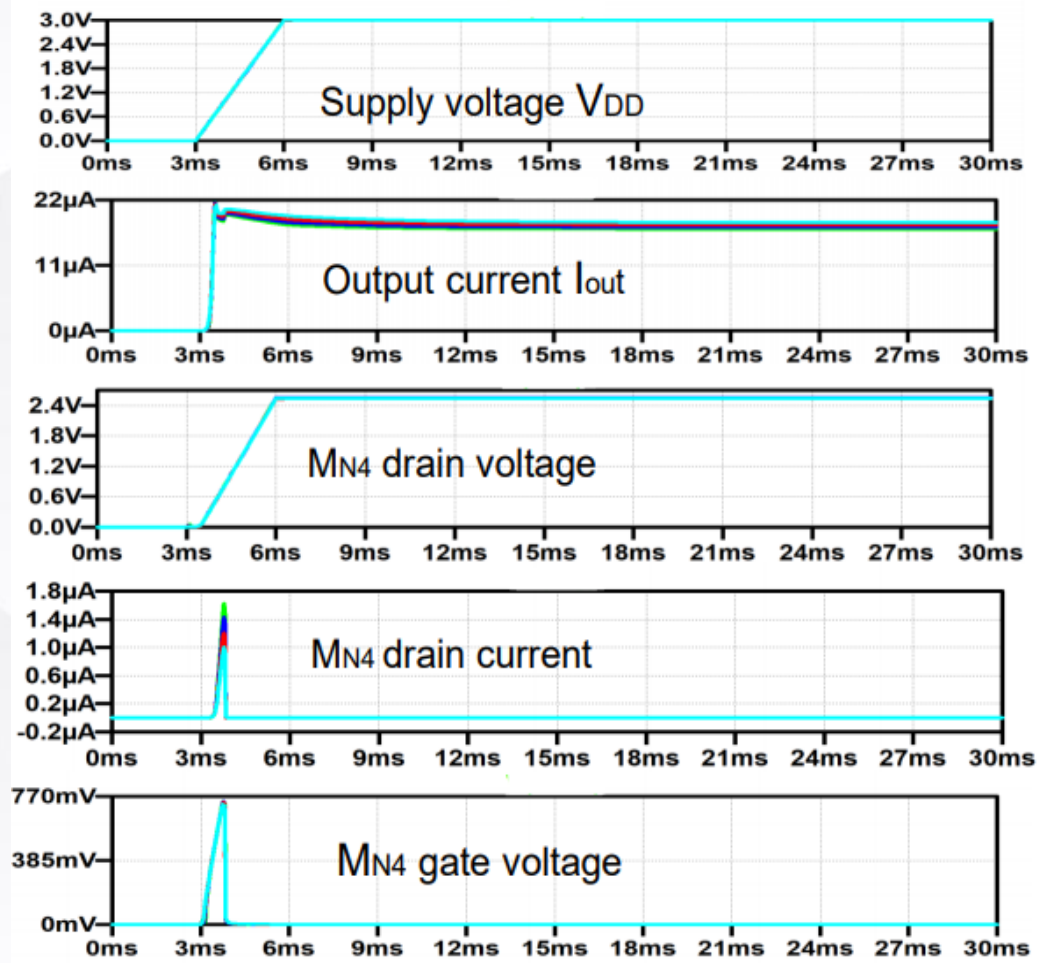
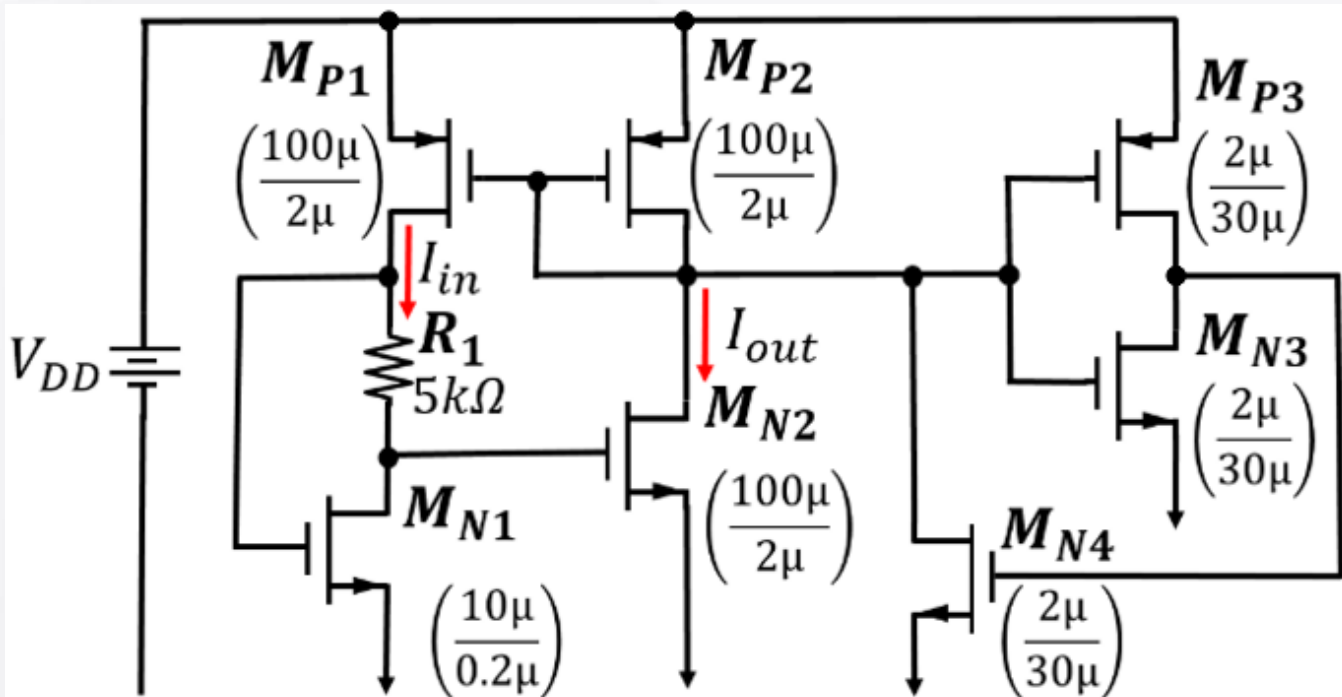
Peaking current source (Nagata current source)



Self-biasing Peaking current source (Nagata current source)



Peaking current source (Nagata current source) with Startup Circuit

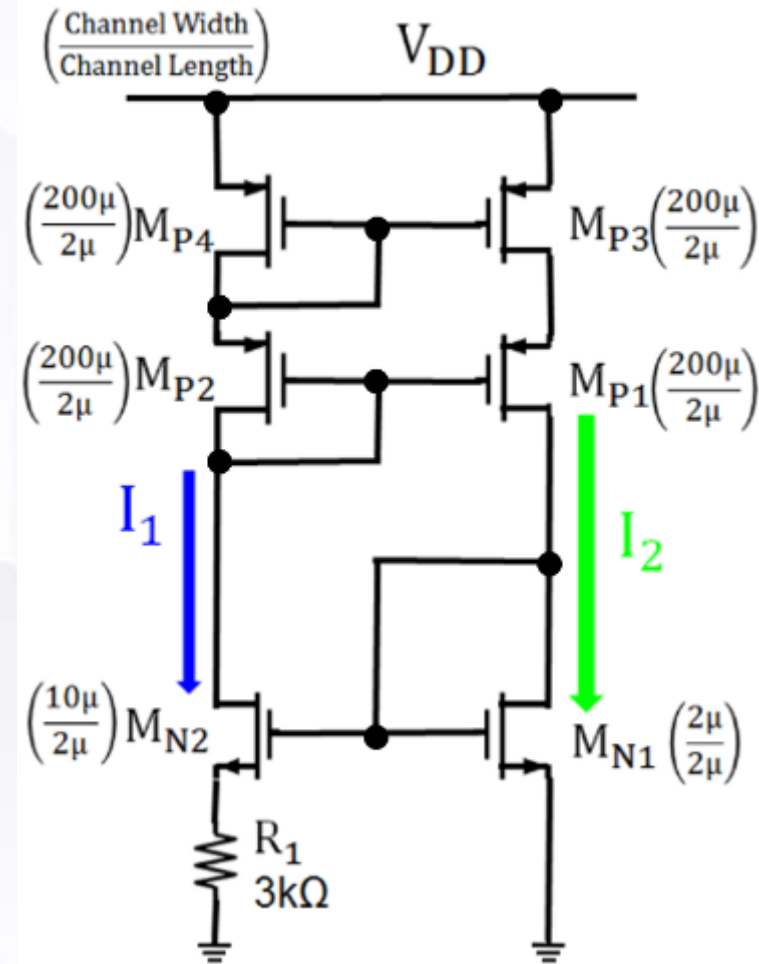
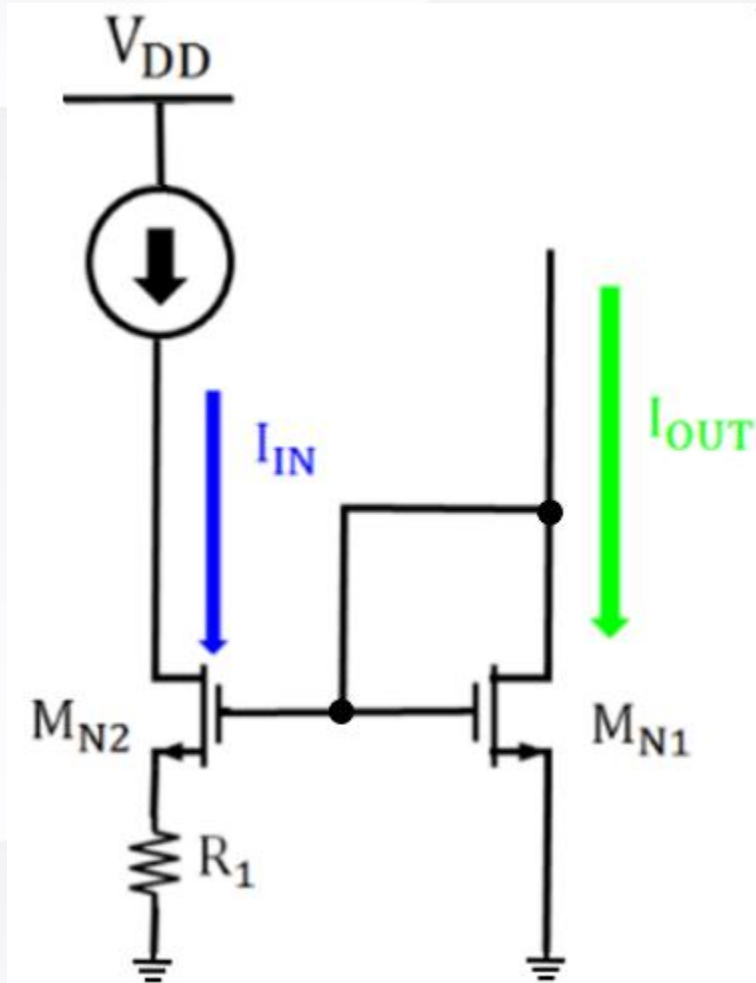


Temperature @ -20°C, 0°C, 27°C, 60°C

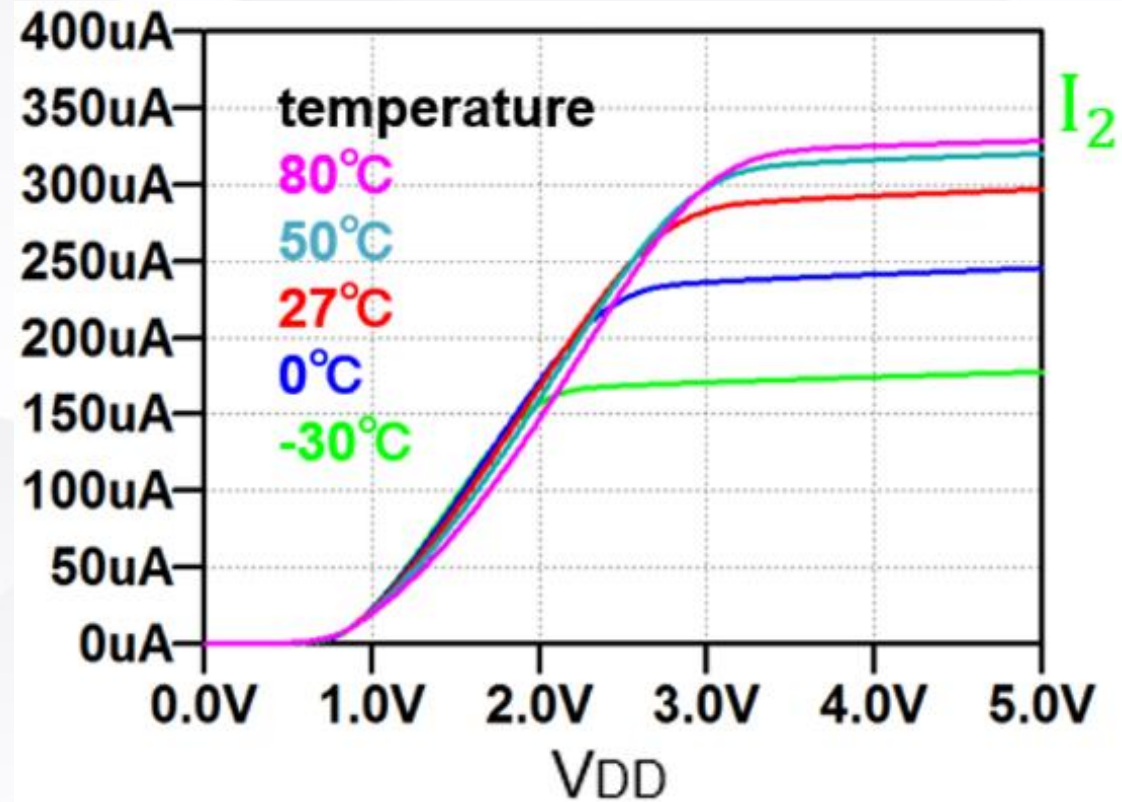
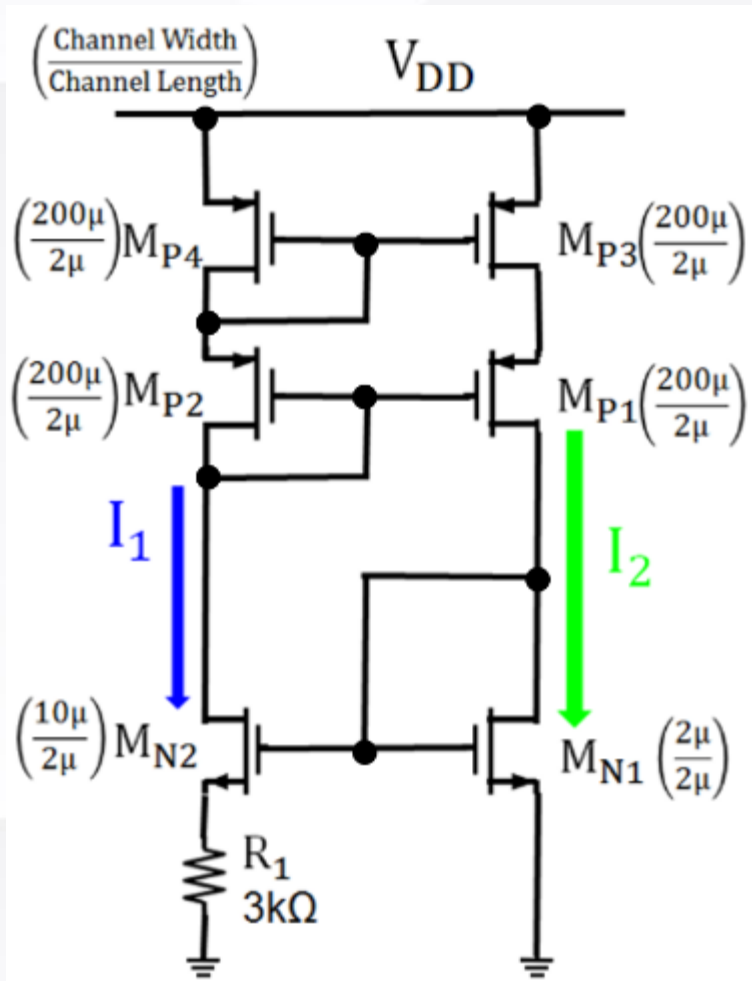
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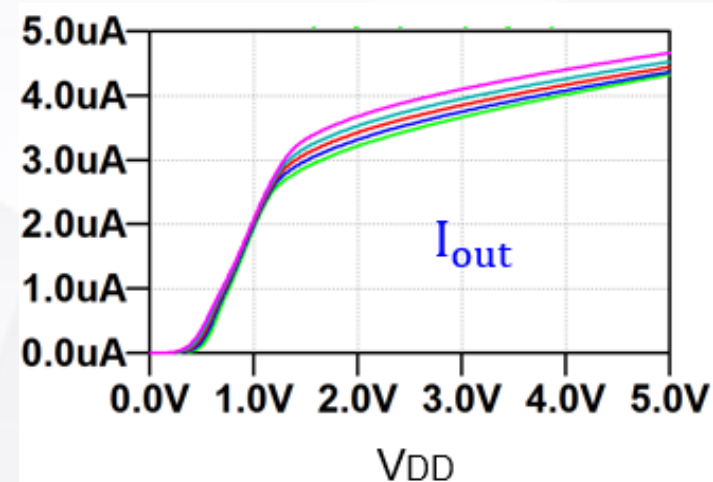
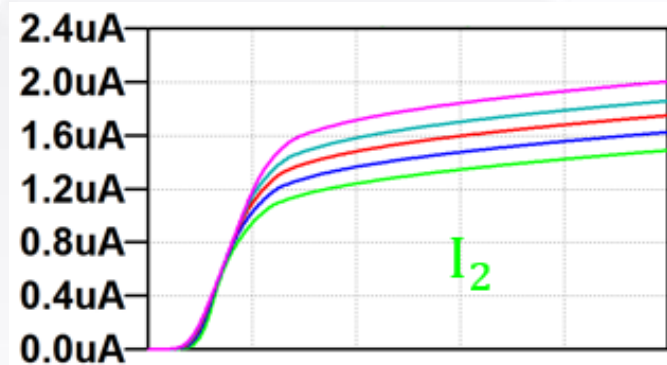
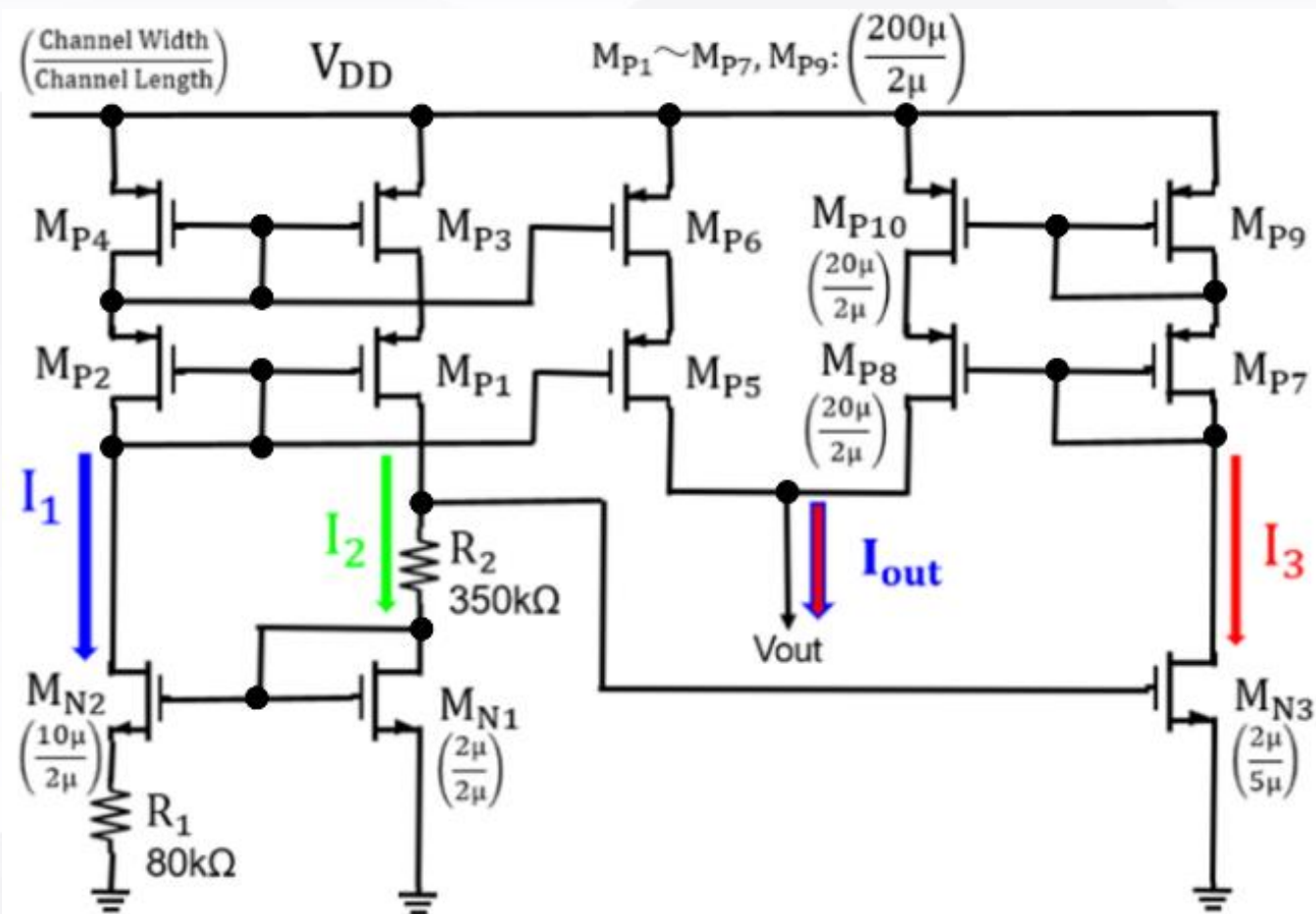
Widlar current source



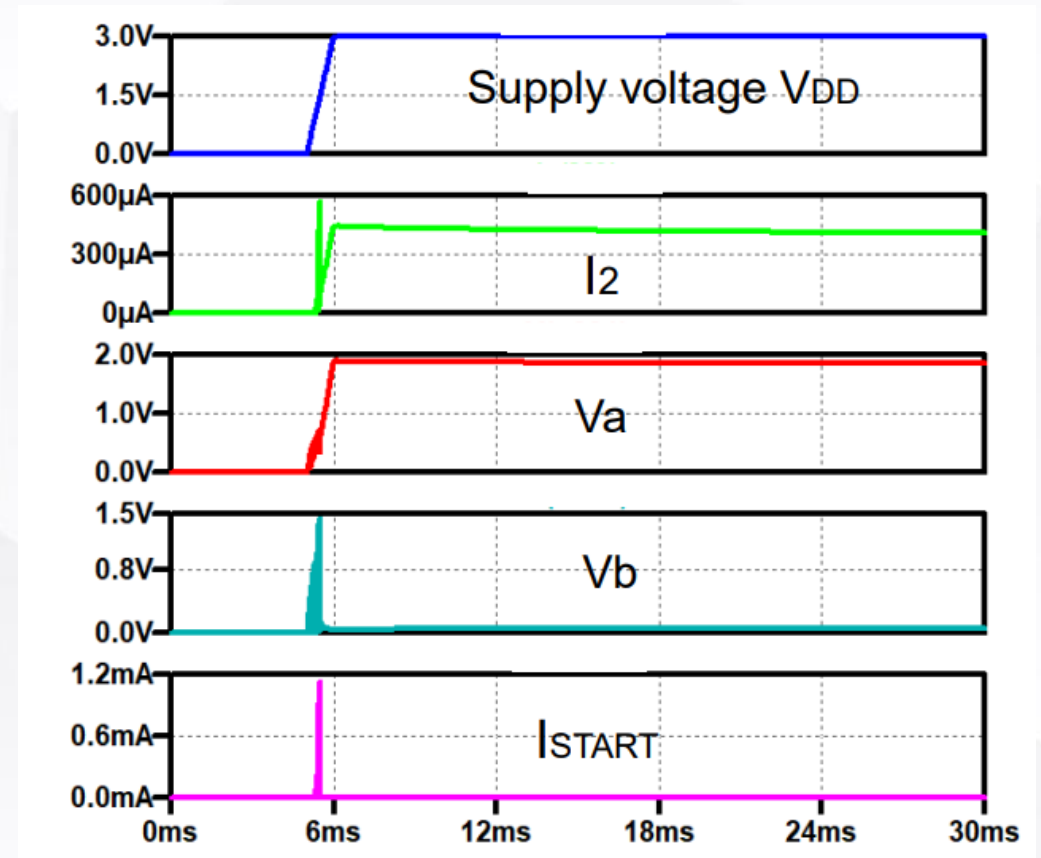
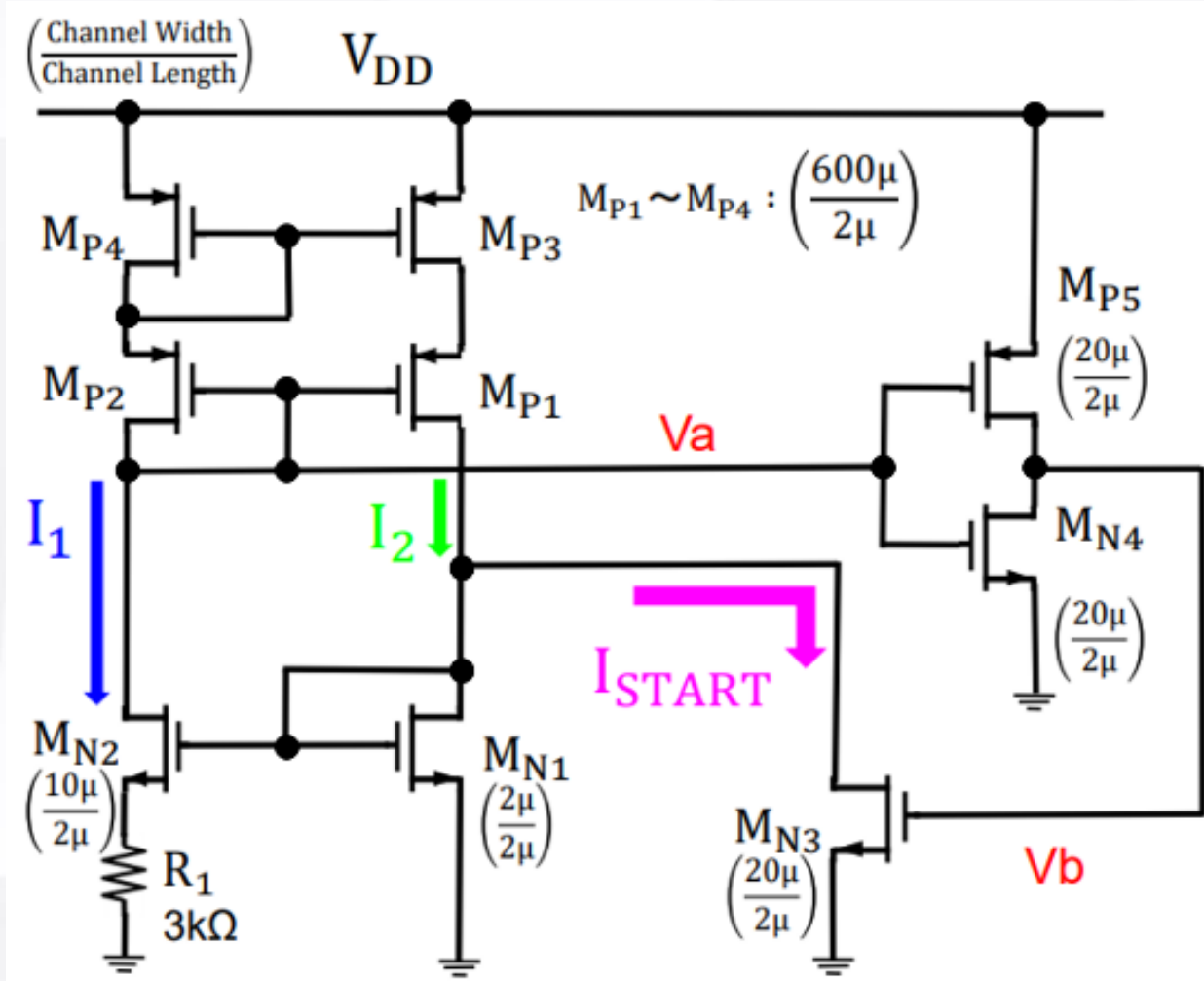
Self-biasing Widlar current source



Temperature sensitivity compensation Widlar



Widlar current source with Startup Circuit



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Conclusion

- We have investigated three types of MOS reference current sources.
- Self-bias and startup circuits are used.
- Temperature-insensitivity is verified.

Remaining work

- Elucidating their pros and cons.

Thank you for your kind attention.