Simple Reference Voltage Generation Circuit Insensitive to Temperature

Lei Sha, Anna Kuwana, Masashi Horiguchi, Haruo Kobayashi

Division of Electronics and Informatics, Gunma University, Japan Email: t191d031@gunma-u.ac.jp

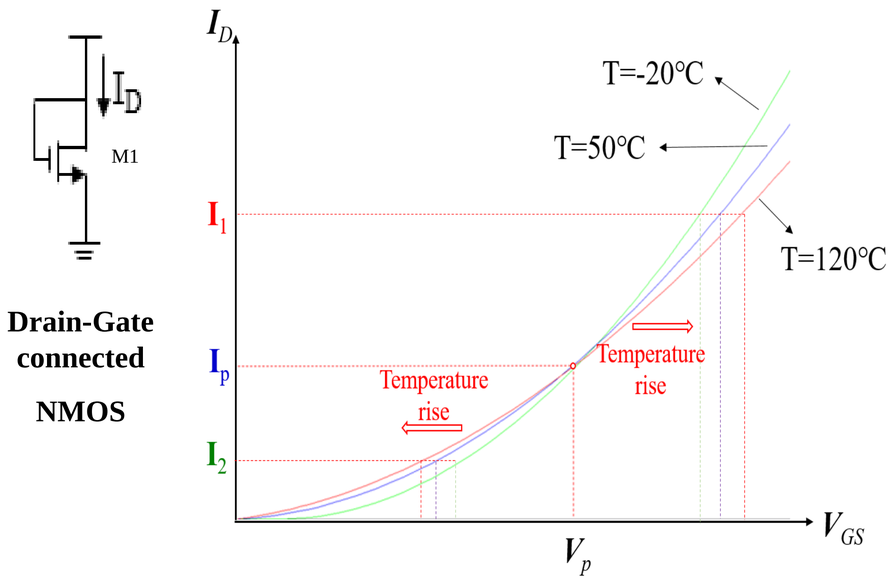
1. Research Objective

- Analog IC requires
  - Operation in wide temperature range
  - One voltage reference

Proposal of a reference voltage generator

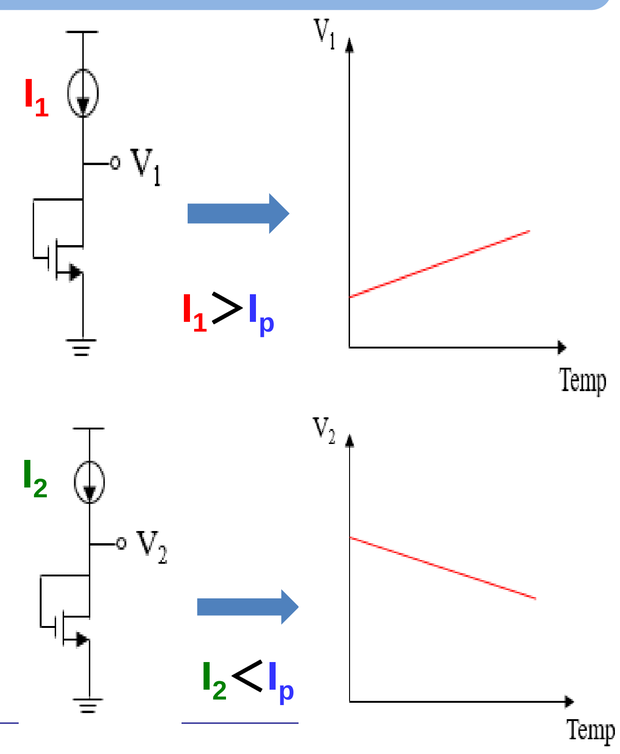
- Insensitive to temperature
- Simple and small
- Only standard CMOS FETs
- Based on MOS temperature characteristics

2. Point of Our Work

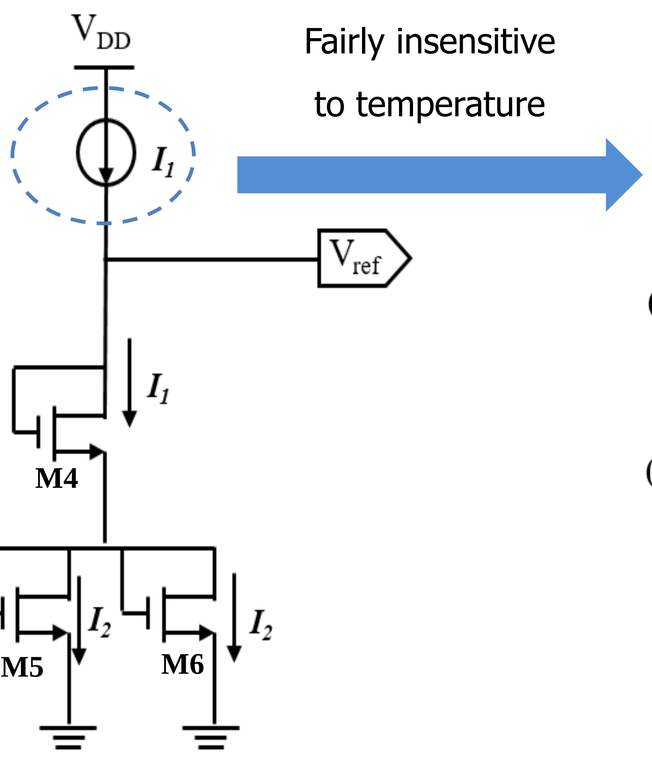


I_D-V_{GS} characteristic of M1

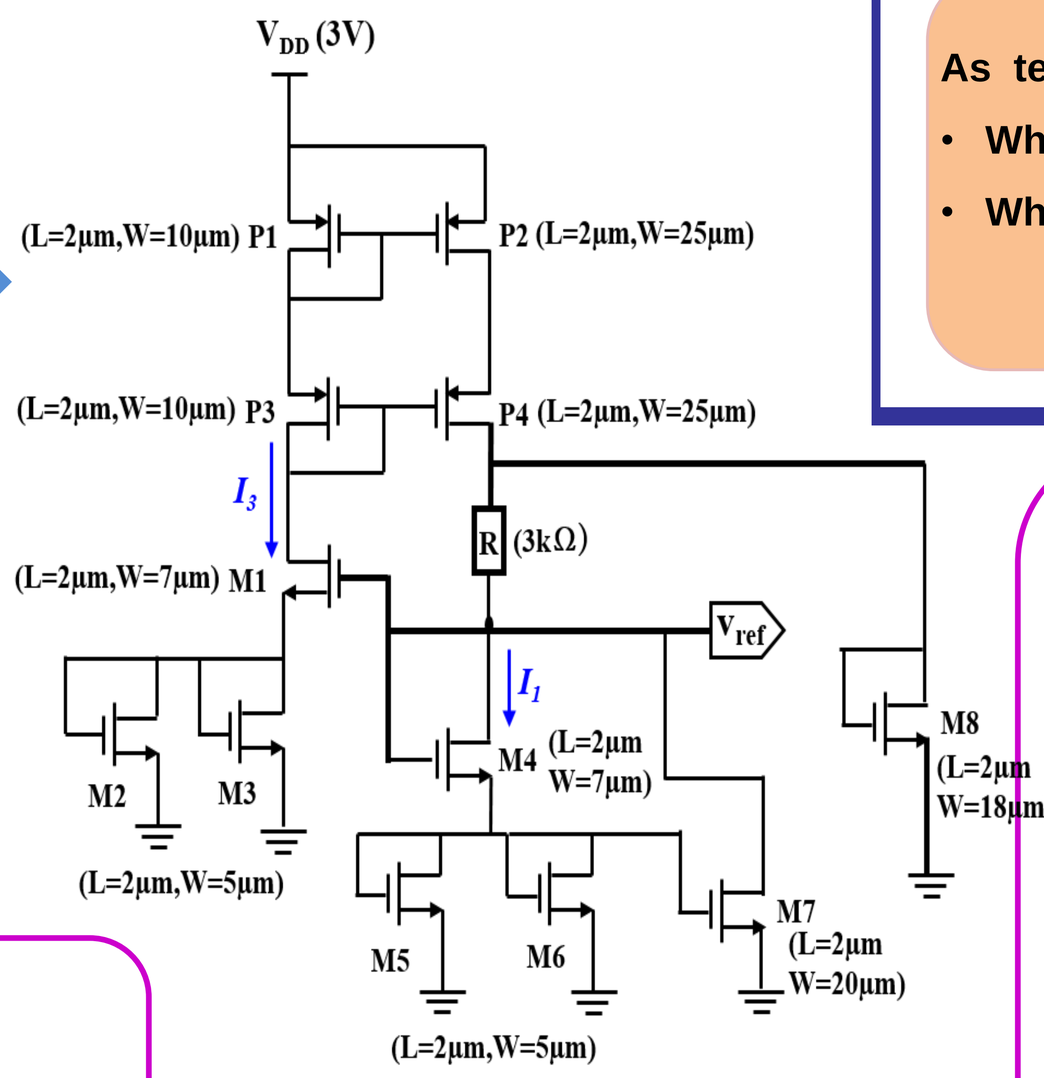
Temperature characteristics of NMOSFET



3.Proposed Circuit



Fairly insensitive to temperature



+ Startup circuit

As temperature rises

- When $I_1 > I_p$, V_{GS} increases.
- When $I_2 < I_p$, V_{GS} decreases.

- P1, P2, P3, P4, M1, M2, M3 compose a constant current source
- M2, M3 adjust input current
- M4, M5, M6 compensate for temperature sensitivity of V_{ref}
- M7, M8 suppress variation of V_{ref} from supply voltage

➢ Large current(I_1) through M4

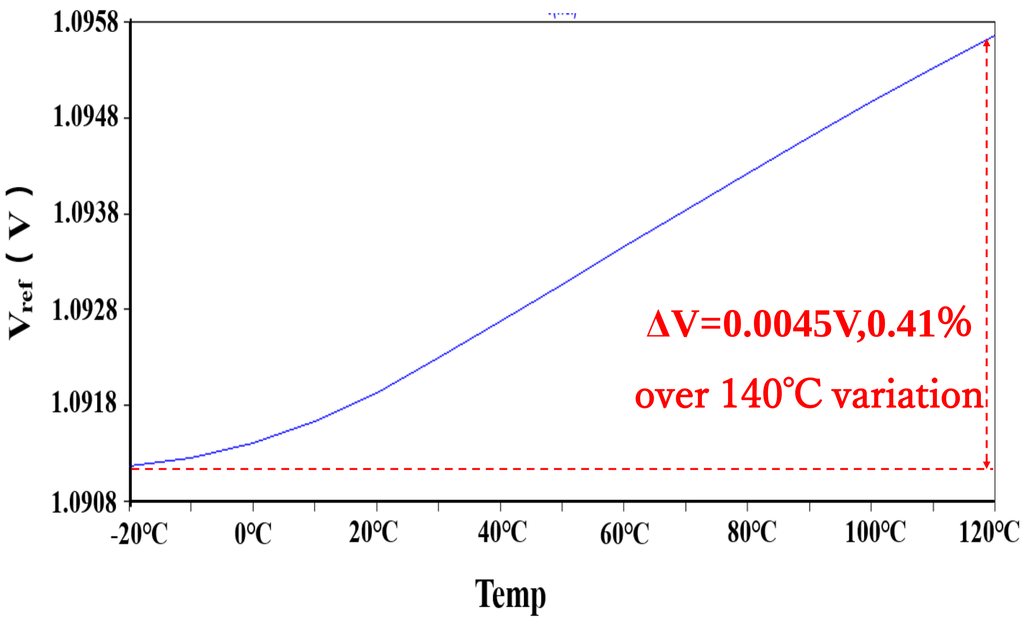
➢ Small current(I_2) through M5, M6

Vref = V_{GS4} + V_{GS5}

Vref temperature characteristics are cancelled.

4. SPICE Simulation Result

Vref temperature characteristics



Supply voltage＝3V

Small temperature coefficient

5.Conclusion

- Small reference voltage deviation

  → 0.0045V from -20℃ to 120℃ for supply voltage of 3V.

- Next step：focus on supply voltage

  → Make reference voltage insensitive to power supply voltage.

References

[1]I. Lee, D. Blaauw, “A 31 pW-to-113nW Hybrid BJT and CMOS Voltage Reference with 3.6% ±3δ-inaccuracy from 0℃ to 170℃ for Low-Power High-Temperature IoT Systems”, VLSI Circuit Symp (2019)

[2]T. Ida, N. Tsukiji, Y. Shibasaki A. Kuwana, H. Kobayashi, “MOS Reference Current Source Insensitive to Temperature Variation”, ICMEMIS, Kiryu (Nov. 2018)