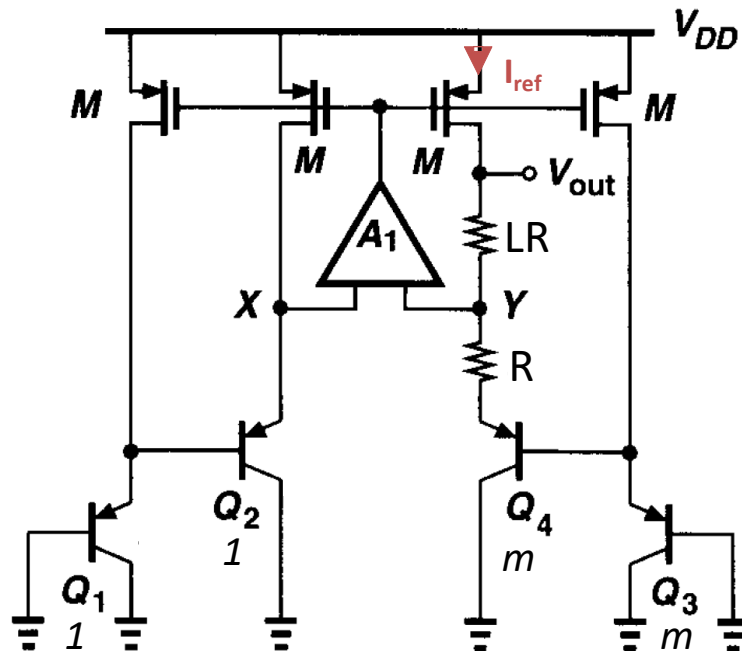


Série N3: Band-Gap Reference

Exercise:



Neglect the channel modulation of the MOSFETS and the base currents of the BJTs. The OpAmp is supposed ideal. Q4 and Q3 are composed on m bipolars in parallel.

- 1- Show the inverting and non-inverting node of the OpAmp on the schematic and justify your choice.
- 2- Give the expression of I_{ref} versus temperature. Is-it PTAT or CTAT?
- 3- Give the expression of V_{out} and $\partial V_{out}/\partial T$.
- 4- Determine the value of L in order to have a bandgap reference (i.e. Temperature independent reference).
- 5- Numerical application: For $m = 8$, $T = 300K$ and $n = 1$
 - a. Determine: L, and V_{out} .
- 6- Assume that bipolar transistors have a finite current gain β (i.e. we consider their base currents). Calculate the error in the output voltage V_{out} .
- 7- Suppose that OpAmp has an offset voltage V_{os} (i.e. Voltage difference at the input of the OpAmp $V_+ - V_-$ is not zero but V_{os}). Calculate the error in the output voltage V_{out} .
- 8- Comment on the effect of the two BJT/branch compared to the topology with only one BJT/branch.
- 9- Is this topology useful for a sub-1V bandgap?