1C-06

Improved Nagata Current Mirror Insensitive to Temperature as well as Supply Voltage

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1.Objective

Most analog ICs require

reference current/voltage source

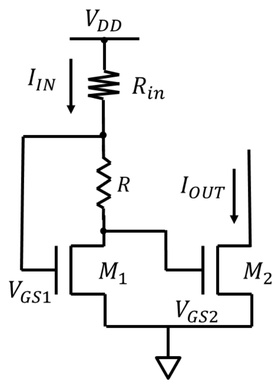
Stable against PVT variation

P : Process
V : Supply voltage
T : Temperature

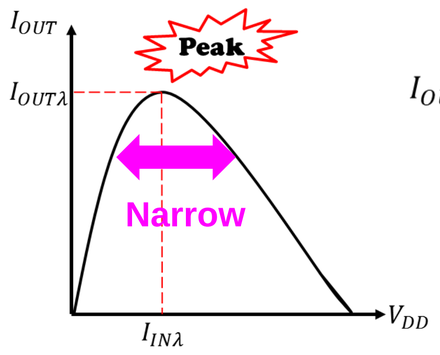
Focus on supply voltage (V) and temperature (T)

2.Background

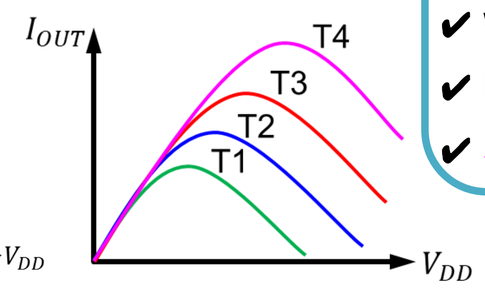
Original Nagata Current Mirror Circuit



MOS Nagata Current Mirror Circuit



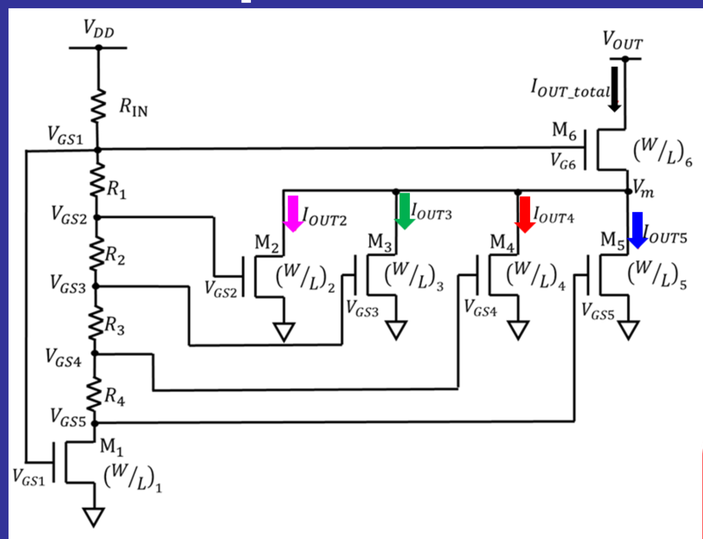
Peaking current characteristics



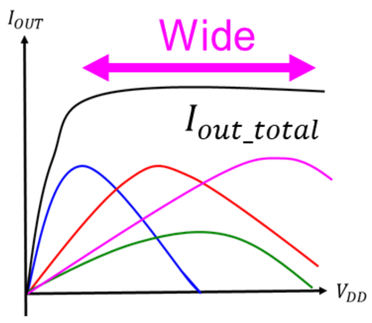
Peaking current characteristics with temperature

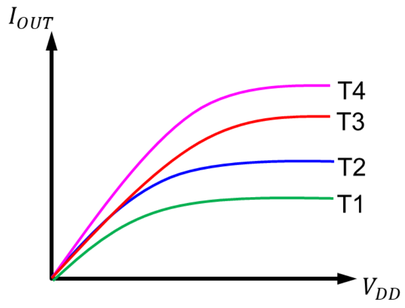
- ✔ Simple
- ✔ Constant current for supply voltage variations
- ✔ Widely used in analog ICs
- ✔ Peak vicinity is very narrow
- ✔ Sensitive to temperature variation

3. Proposed Circuit

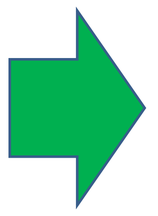


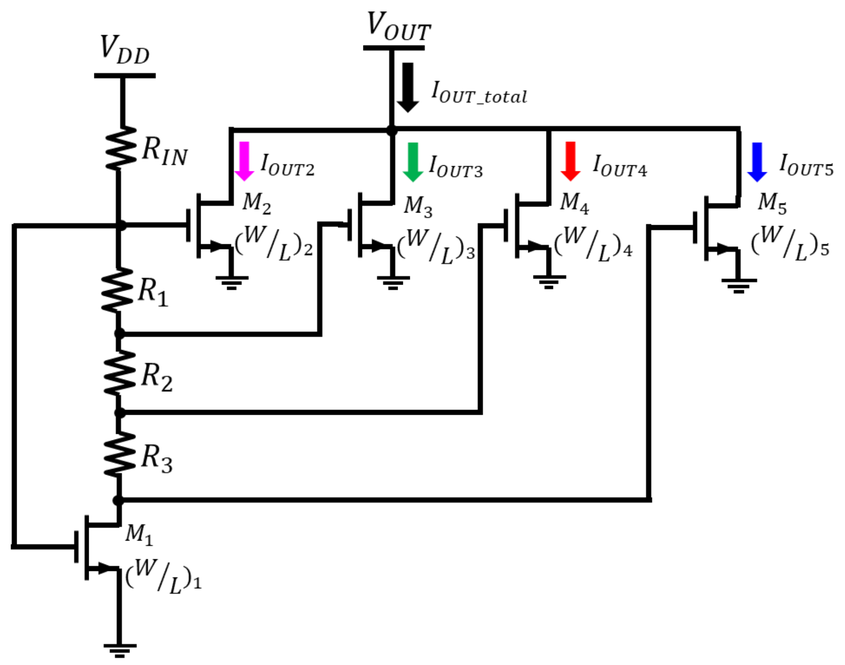
Conventional circuit by M. Hirano





- ✔ Simple design
- ✔ Using multiple current mirror circuit with different current peaks
- ✔ Sensitive to temperature variation





Proposed circuit

4.Simulation Results

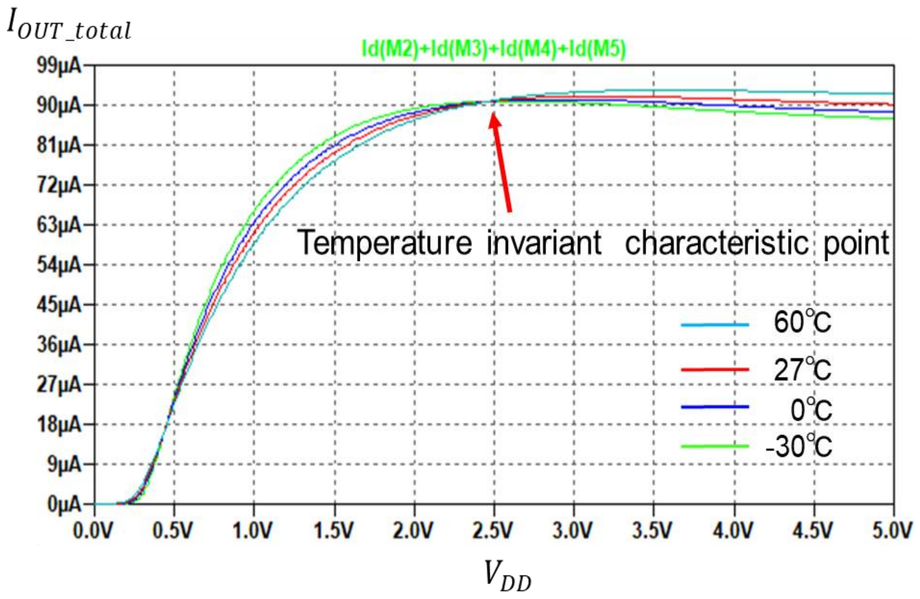
Parameters

$W_1[\mu m]$	1	$L_1[\mu m]$	0.2	$R_1[k\Omega]$	6
$W_2[\mu m]$	0.5	$L_2[\mu m]$	0.2	$R_2[k\Omega]$	9
$W_3[\mu m]$	3	$L_3[\mu m]$	0.2	$R_3[k\Omega]$	11
$W_4[\mu m]$	6	$L_4[\mu m]$	0.2	$R_{IN}[k\Omega]$	500
$W_5[\mu m]$	6	$L_5[\mu m]$	0.2		

LTspice

TSMC $0.18[\mu m]$ CMOS model

Temperature: -30℃, 0℃, 27℃, 60℃



SPICE simulation result

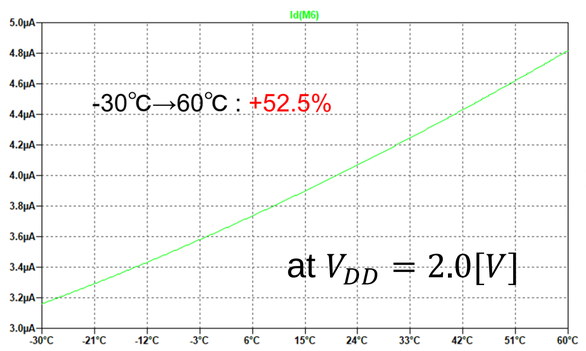
I_{OUT2} *and* I_{OUT3} have Negative temperature characteristics

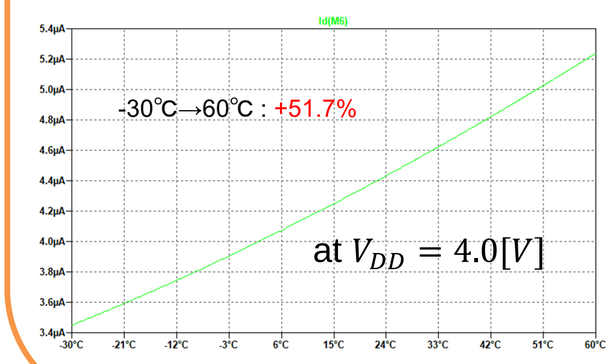
I_{OUT4} *and* I_{OUT5} have Positive temperature characteristics

Cancel the temperature characteristics

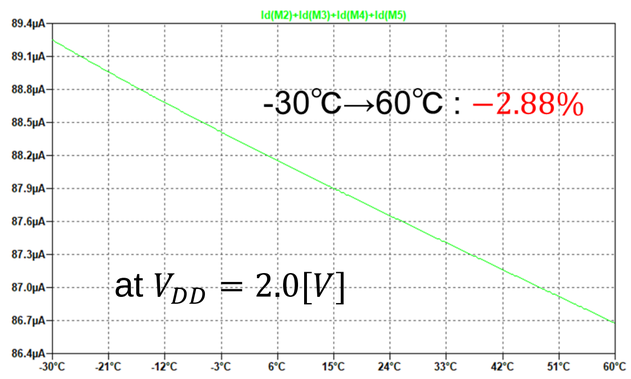
5.Comparison

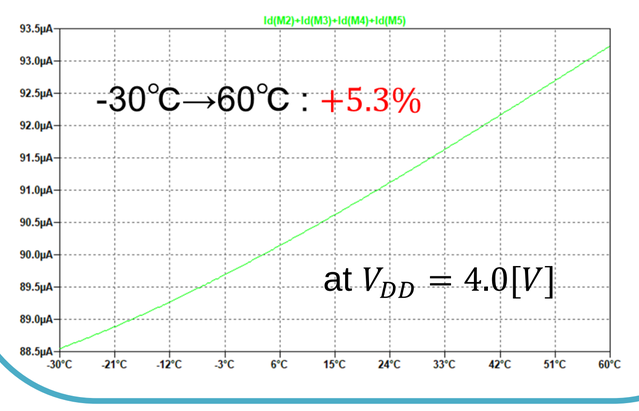
Conventional circuit





Proposed circuit





✔ Proposed circuit is less sensitive to temperature

6.Conclusion

Conventional :

Peak vicinity is very narrow and sensitive to temperature variation

Proposed :

Combining positive and negative temperature characteristics

- ✔ Simple
- ✔ Insensitive to a wide range of power supply voltage variation
- ✔ Insensitive to temperature variation

Reference

[1]M. Hirano, N. Tsukiji, H. Kobayashi, "Simple Reference Current Source Insensitive to Power Supply Voltage Variation - Improved Minoru Nagata Current Source", IEEE 13th International Conference on Solid-State and Integrated Circuit Technology, Hangzhou, China (Oct. 2016).