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**Selected Task : Task 1**

**Project Title :**

Migration of a Sub-1-V CMOS Bandgap Reference Circuit without Extra Low-Threshold Devices to eSim.

**Reference Paper Citation :**

Ming-Dou Ker, Jung-Sheng Chen, and Ching-Yun Chu, "A CMOS Bandgap Reference Circuit for Sub-1-V Operation Without Using Extra Low-Threshold-Voltage Device," Nanoelectronics & Gigascale Systems Laboratory, National Chiao-Tung University.

**Problem Statement :**

Practical CMOS bandgap references are limited by a minimum supply voltage of approximately 1.2V due to the forward voltage of the BJT. This project aims to migrate a novel sub-1-V architecture to the open-source eSim environment. The goal is to verify that the circuit can operate at a supply voltage of 0.85V and maintain a stable output voltage of approximately 238.2 mV with a temperature coefficient of 58.1 ppm/°C.

**Circuit Diagram to Implement :**

1. Parasitic vertical BJT transistors (PNP).
2. An Operational Amplifier (Op-Amp) used for current mirroring.
3. A Start-up circuit (to ensure the circuit doesn't stay in a "zero-current" state).

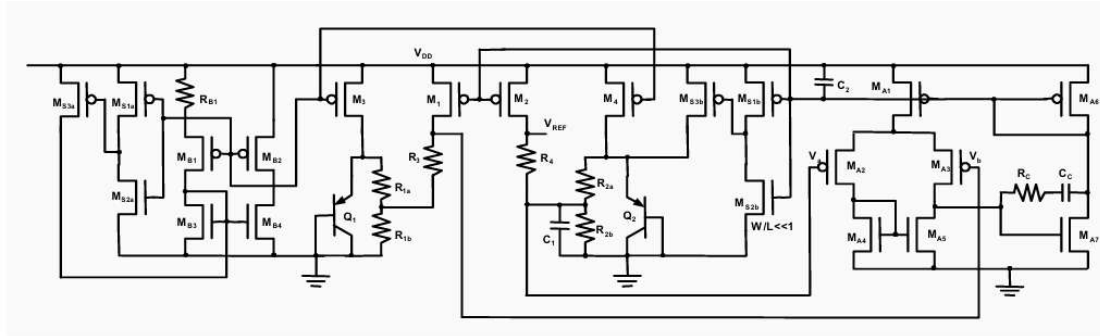


Fig. 3. Complete schematic of the new proposed bandgap reference.

### Theory and Circuit Description :

This project migrates a Sub-1-V CMOS Bandgap Reference to eSim, overcoming the 1.2V limit of traditional designs. The circuit utilizes a current-mode architecture where an Error Amplifier balances two branches containing parasitic PNP BJTs to generate CTAT and PTAT currents. These currents are summed and driven through a load resistor ( $R_2$ ) to produce a stable output voltage ( $V_{ref}$ ) as low as **0.85V**. A integrated Startup Circuit ( $M_{S1}$ – $M_{S5}$ ) is included to prevent the simulation from getting stuck in a zero-current state. By balancing the opposing temperature coefficients of the BJT base-emitter voltage and the thermal voltage, the circuit achieves high thermal stability. The final implementation in eSim verifies that a precise **238.2 mV** reference is maintained across a wide temperature range using a standard  $0.25\mu\text{m}$  process.