Self-Biased Sub-1V Bandgap Reference Circuit

Bilal Ramadan

Supervisor: Dr. Hesham Omran

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Part 1: Design Required Specs

Technology	$65\ nm\ CMOS$
Supply Voltage	$2\ V$
Output voltage	$800\ mV$
Change versus Temperature	$< 1\ mV$
Change across Corners	$< 10\ mV$
Current consumption	$< 10\ \mu A$
Phase margin	$> 60°$

Table 1: Required specs

The Design will be on three phases as follows:

Part 2: BGR Core Circuit

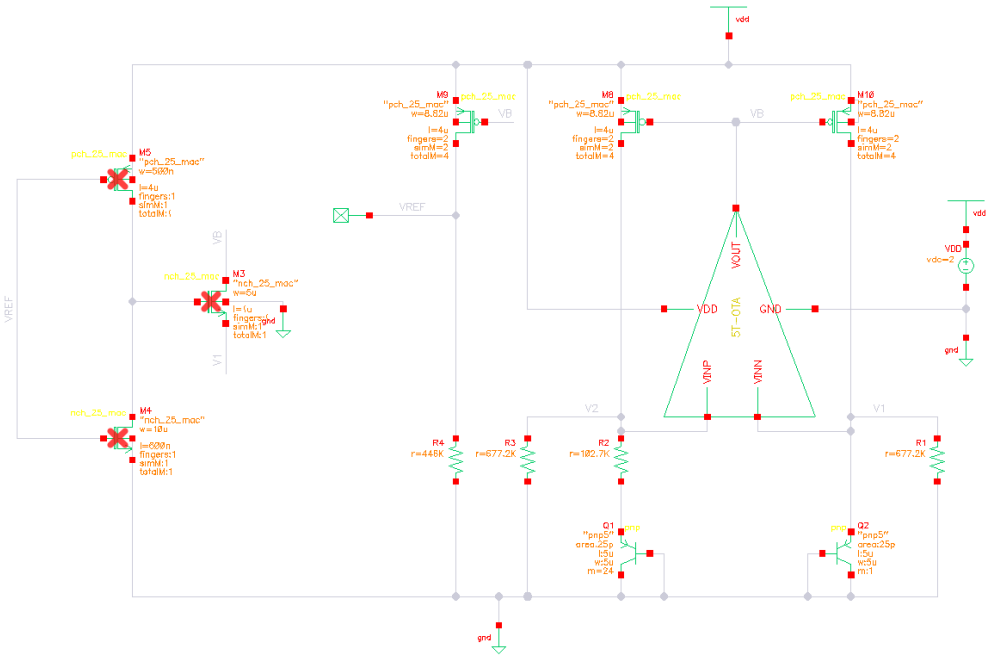

Figure 1: schematic

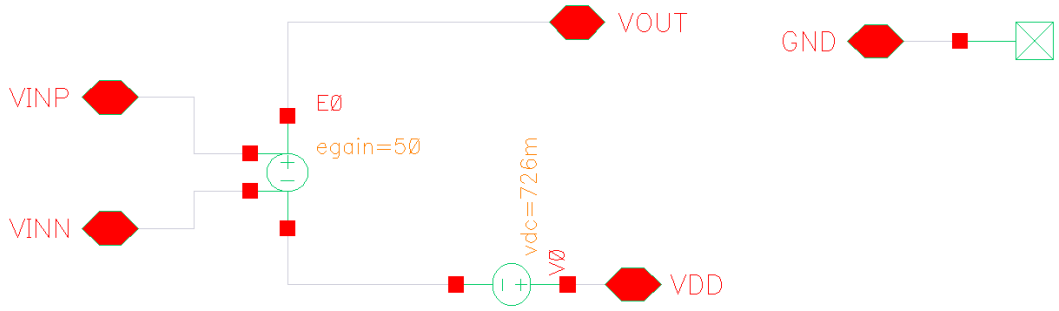

Figure 2: Error amplifier behavioral model

1. OP simulation

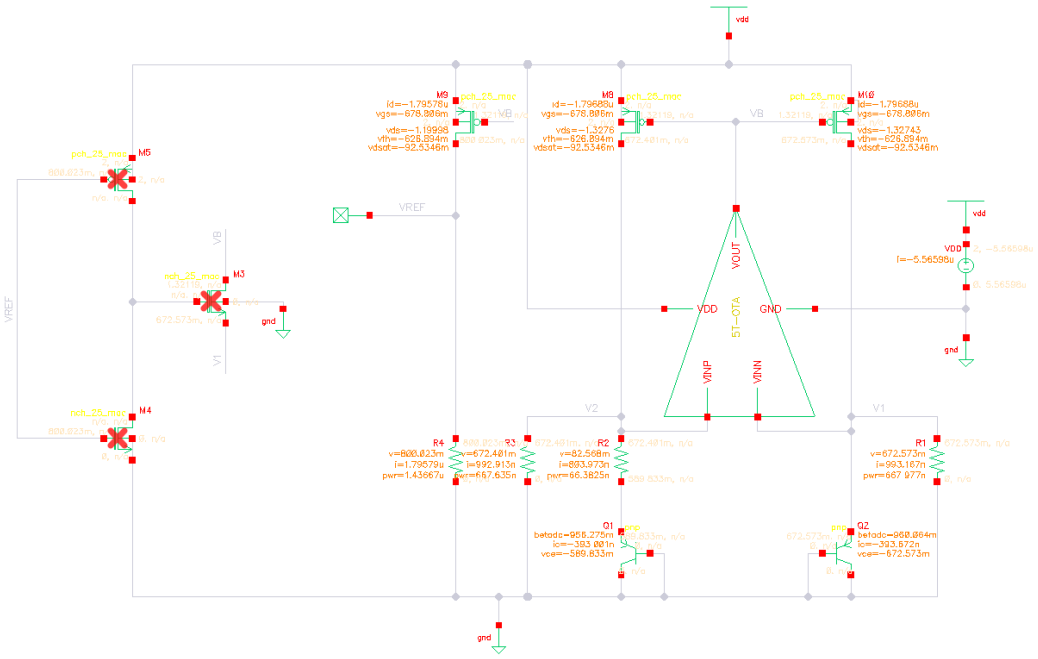

Figure 3: schematic with DC OP and node voltages annotated

2. DC temperature sweep simulation

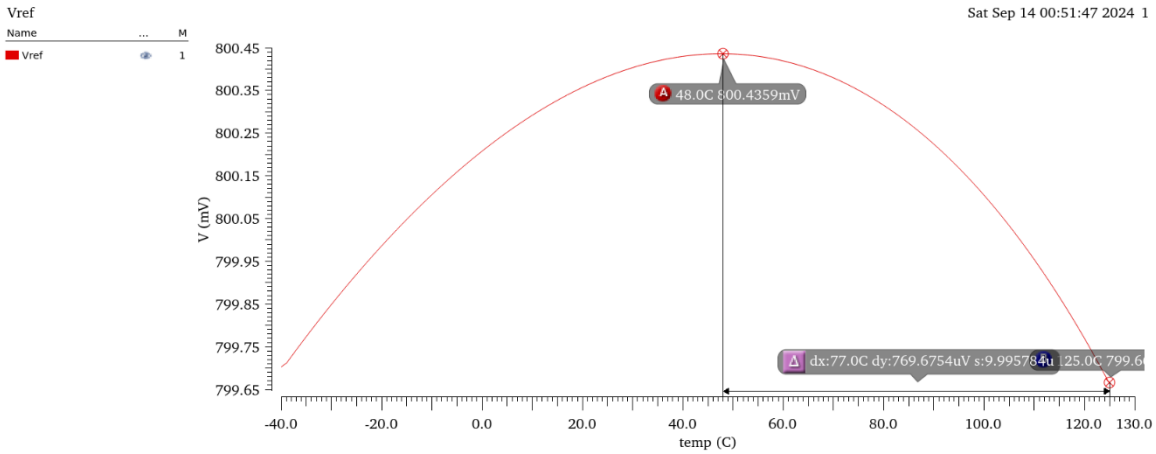

Figure 4: Vref vs temperature with 0.8 mV change

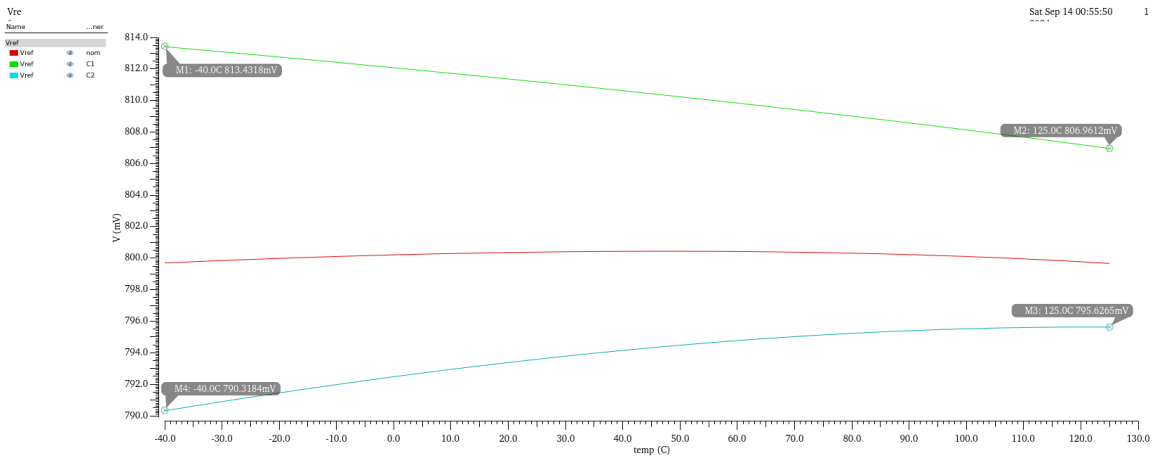

Figure 5: Vref across corners

Part 3: Error Amplifier

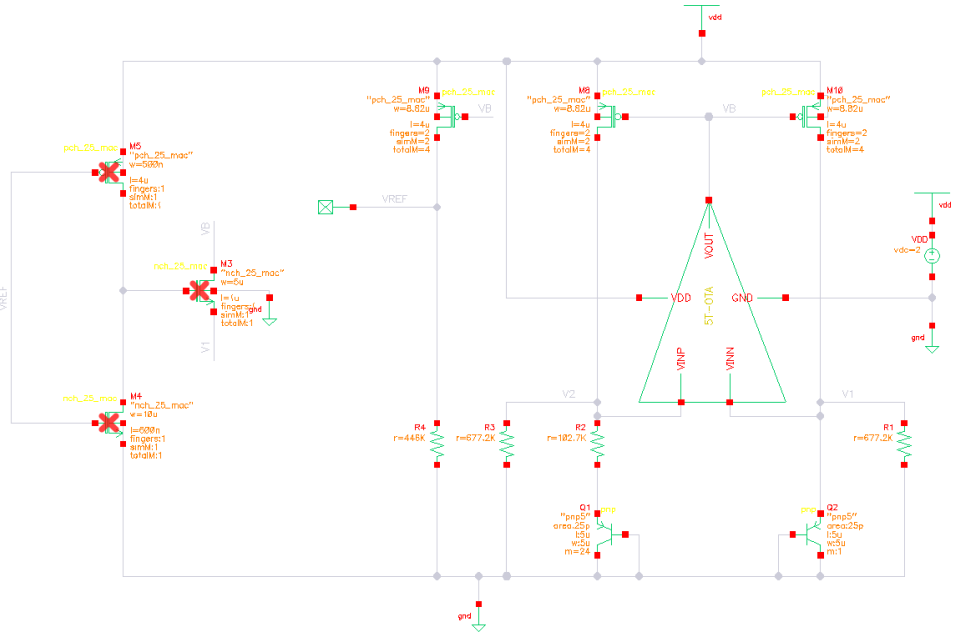

Figure 6: schematic

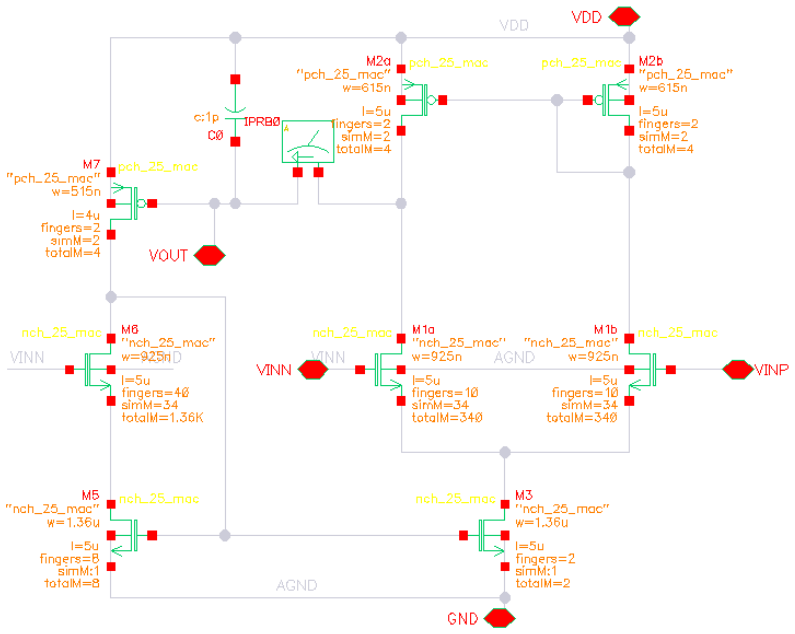

Figure 7: Error amplifier schematic

1. OP simulation

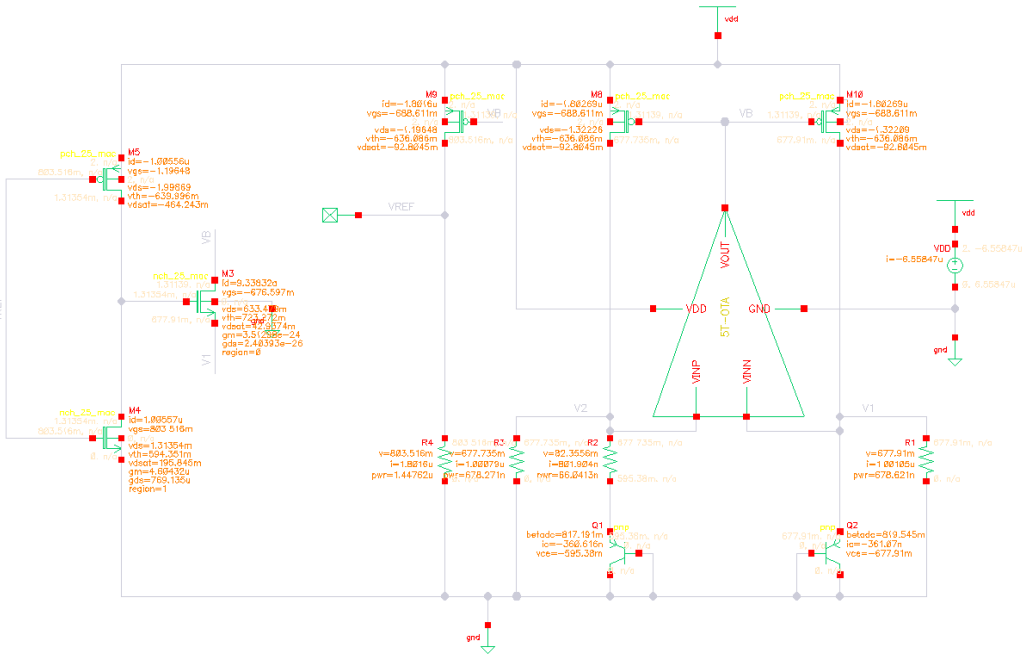

Figure 8: schematic with DC OP and node voltages annotated

Total Current consumption = 6.6 μA

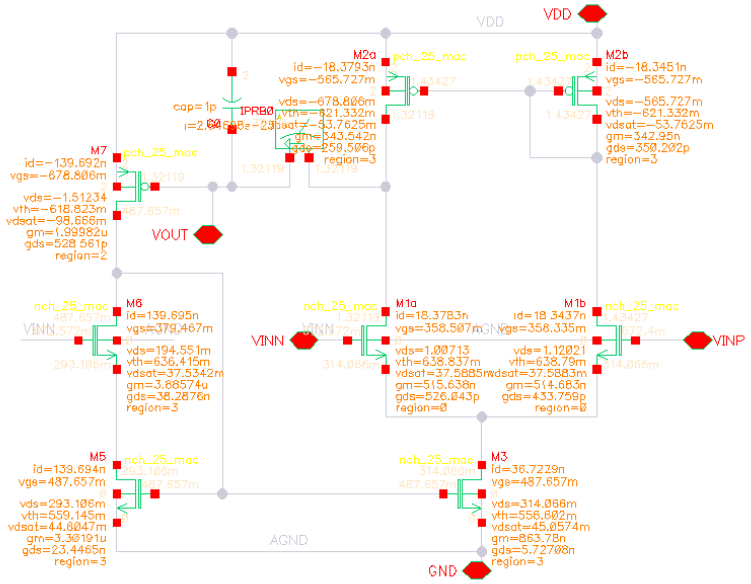

Figure 9: Error amplifier schematic with DC OP and node voltages annotated

2. DC temperature sweep simulation

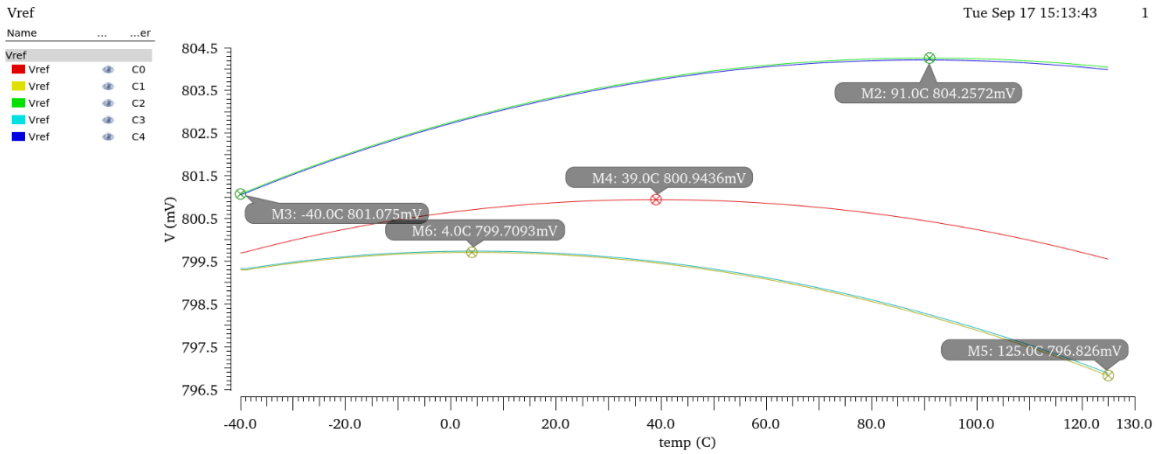

Figure 10: Vref across corners with 3.2 mV maximum change versus temperature

3. Stability analysis

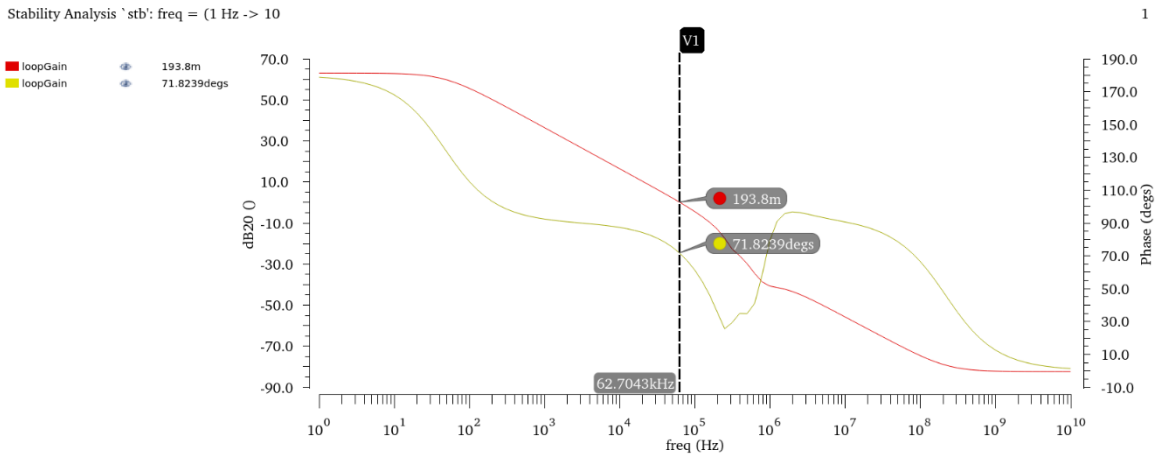

Figure 11: Gain crossover frequency

$PM = 72^o$

Part 4: Startup Circuit

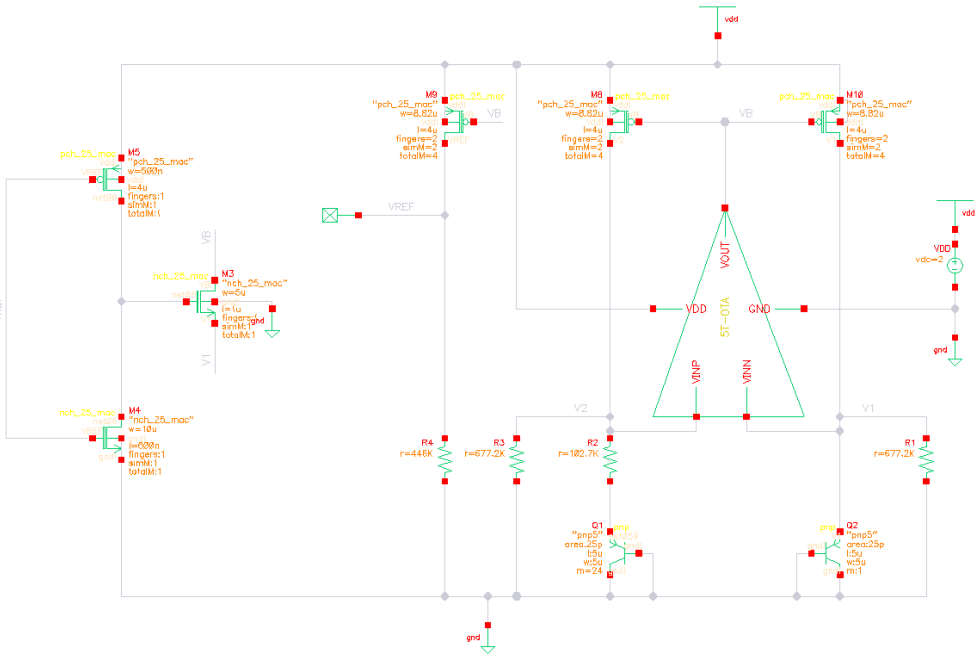

Figure 12: schematic

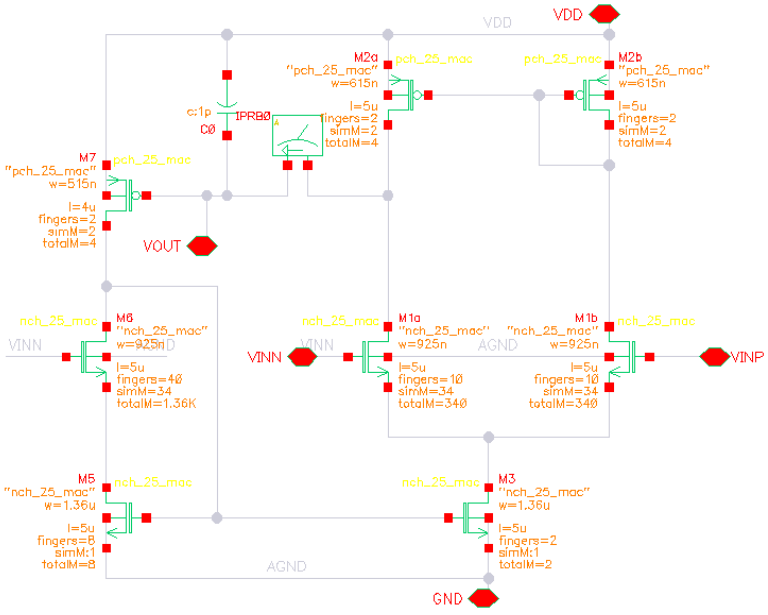

Figure 13: Error amplifier schematic

1. OP simulation

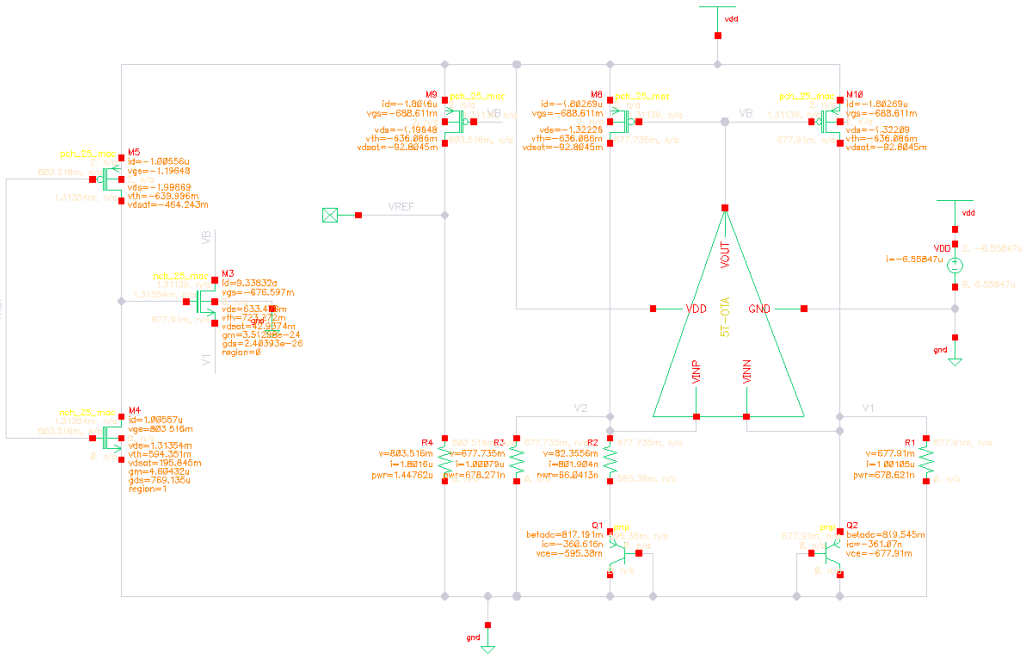

Figure 14: schematic with DC OP and node voltages annotated

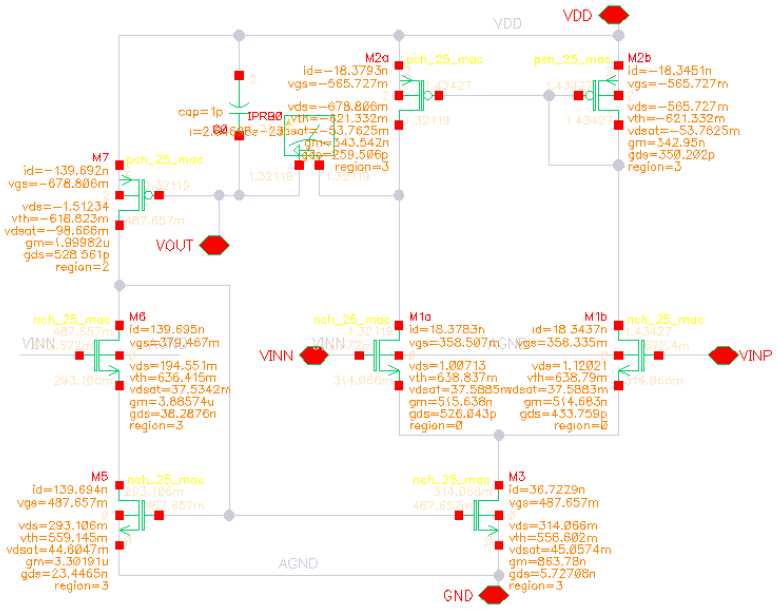

Figure 15: Error amplifier schematic with DC OP and node voltages annotated

2. Transient analysis supply ramp

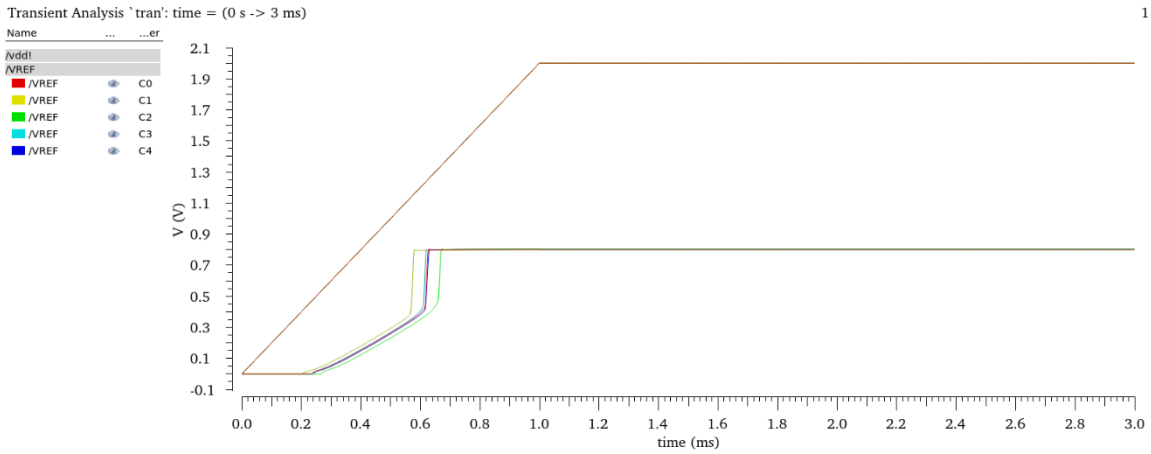

Figure 16: Transient Vref across corners at room temperature

Part 5: Achieved Specs

Spec	Required	Achieved
Supply Voltage	$2\ V$	$2\ V$
Output Voltage	$800\ mV$	$800\ mV$
Change versus Temperature	$< 1\ mV$	$0.8\ mV$
Change across Corners	$< 10\ mV$	$3.2\ mV$
Current consumption	$< 10\ \mu A$	$6.6\ \mu A$
Phase margin	$> 60°$	$72°$

Table 2: Achieved specs