ECE 444 – Design Project
Temperature Stabilized Ring Oscillator Using a Band-gap Reference Voltage Source

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Introduction. The output frequency of a CMOS ring oscillator is strongly dependent on both the operating temperature and the supply voltage. The frequency increases with increasing supply voltage, and increases with decreasing temperature.

Part A. Design a ring oscillator, using the 65nm CMOS process, that has a nominal oscillation frequency of 3 GHz at a temperature of 27°C and supply voltage of ~ 1 V. Simulate the oscillation frequency as a function of temperature (0° to 100° C) and supply voltage (0.8 - 1.4 V). Determine the required supply voltage as a function of temperature needed to stabilize the oscillation frequency at 3 GHz as the temperature is varied between 0° and 100° C.

Part B. Design a band-gap reference circuit, using the 350nm process, to generate the supply voltage for the ring oscillator. This supply voltage should have a temperature dependence as determined in Part A. The operational amplifier used in the band-gap reference circuit should be biased using a boot-strapped bias circuit. The band-gap reference circuit should compensate for the frequency variation due to temperature so that the oscillation frequency remains close to 3 GHz as the temperature is varied between 0° and 100° C, and the external supply voltage, used to the band-gap reference circuit, is varied between 3.1 and 3.5 V.

Design a second band-gap reference circuit to provide a stable 1.2 V output, independent of temperature. This voltage will serve as a supply voltage for an inverter connected to the output of the ring oscillator so that the oscillation voltage remains at 1.2 V, independent of temperature and the external supply voltage.

Report. Characterize the ring oscillator powered by the band-gap reference circuits. Plot the output voltage and frequency as a function of temperature, from 0° to 100° C, and supply voltage, from 3.1 to 3.5 V. For a well designed band-gap reference circuit, the output voltage and frequency should remain nearly constant. A preliminary report describing the results from Part A will be due mid-semester. A final project report describing the design for Part B will be due during final's week.

Designs with minimal variation in the output frequency as a function of the supply voltage and temperature will be considered superior.

Specifications.

1. Nominal oscillation frequency: 3 GHz
2. Input voltage: 3.1 – 3.5 V (single rail)
3. Output voltage: 1.2 $\pm$ 0.02 V
4. Temperature: 0° to 100°C
5. Variation in output frequency: minimal