Reference Circuits

- External bias current not always available
  - May need to generate reference internally

- Tons of “constant X” reference circuits in the literature
  - Important considerations include power, accuracy, PSRR, output impedance, etc.

- Most important question: what do you really want to be constant?
Constant Current Bias?

Constant Gain Example
Supply “Independent” Biasing

Improved $V_{GS}$ Reference
PTAT Reference

CMOS PTAT Reference

[Diagram of CMOS circuit with labels for substrate, well, and diffusion regions]
Startup Circuit

Conceptual Band-Gap

- $V_{BE}$ has a tempco of roughly -2 mV/°C
- Add $V_{BE}$ to PTAT voltage (with right M) $\rightarrow V_{bg}$ independent of T
- Reference derived from band-gap of Si (1.205V)