Biasing: Current Mirror
Biasing: Cascode

Reference Circuits

• Where did those constant currents come from?
  • May need to generate those internally – usually known as a "reference"

• 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
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)
Constant $g_m$ Reference