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 Gain Example

Supply “Independent” Biasing

Constant Current Bias?

Improved $V_{GS}$ Reference
PTAT Reference

- **CMOS PTAT Reference**

  - **p** substrate
  - **p** diffusion
  - **n** well
  - **n** diffusion

  ![CMOS PTAT Reference Diagram](image)

- **Startup Circuit**

Conceptual Band-Gap

- \( V_{bg} = V_{CEO} + V_{T} \left( 1 + \ln \frac{T}{T_{ref}} \right) \)
- **VBE** has a tempco of roughly -2 mV/°C
- Add **VBE** 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

- **Startup Circuit Diagram**

- **CMOS PTAT Reference Diagram**