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**

**Startup Circuit**

**Conceptual Band-Gap**

\[ V_{bg} = V_{BE} + V_T (\gamma - \alpha) \left( 1 + \ln \frac{T_{ref}}{T} \right) \]

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

**Constant \( g_m \) Reference**