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?

Supply “Independent” Biasing

Improved $V_{GS}$ Reference
**PTAT Reference**

**Conceptual Band-Gap**

\[ V_{bg} = V_{E0} + V_T (1 + \frac{1}{e^{V_{BE}/V_T}}) \]

- \( V_{BE} \) 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)

**CMOS PTAT Reference**

**Constant \( g_m \) Reference**

**Startup Circuit**