Simulating Stability

- \( T(s) \) can be very tricky to find in simulation
- Need to decouple transistor parasitics from the transistor
  - No generally perfect way to do this

Middlebrook Method (1975)

\[
\begin{align*}
T &= g_m Z_1 + Z_2 \\
\text{Solving yields:} & \quad T = \frac{g_m Z_1 + Z_2}{Z_1 + Z_2}
\end{align*}
\]

- Measure \( T_v \) and \( T_i \), then calculate actual \( T \)

Simple Circuit Example

- Stability often set by non-dominant poles
  - Ignore \( r_o \) to simplify analysis
  - Feedback factor: \( F = \frac{C_f}{C_i + C_f} \)

Common Approach

- Implies small \( C_f \) is desirable (min. loading)
  - Careful with noise…

Loop Gain

\[
T(s) = \frac{C_f (C_i + C_f)}{C_f + C_i + C_f}
\]

- \( C_{f,\text{on}} = C_f \) when \( C_i \) is large

\[
T_{\text{on}} = \frac{C_f (C_i + C_f)}{C_f + C_i + C_f}
\]

- \( C_{f,\text{off}} = C_f \) when \( C_i \) is small

\[
T_{\text{off}} = \frac{C_f C_i}{C_f + C_i + C_f}
\]
Closed-Loop Gain

- CL transfer function (ignoring $r_o$):
  \[ A_v = \frac{V_o}{V_i} = \frac{C_s}{C_f} \left( \frac{1-sC_s/g_m}{1+sC_f/\left(Fg_m\right)} \right) \]
- Why RHP zero?
  - Feedforward current

Noise

Design Procedure (Example)

- Given DR, calculate $C_L$
  - Actually loaded by $C_{L_{eff}}$, but ignore that at first
- Given BW, calculate $g_m$
- Choose $V^*$
  - Tradeoffs:
    - Low $V^*$: good $g_m/I_d$
    - High $V^*$: lower $C_s$, larger $F$
  - (Usually start with low $V^*$)
- Calculate $W$
  - Now know $C_i$ - can fix $C_f$ (noise)
  - Re-iterate based on new $C_{L_{eff}}$