

# TIA Circuit Design Notes

Minimal cheat-sheet · vector, monochrome · copy-ready formulas & quick flows

## Core

$$V_{out} = V_{ref} - I_{in} \cdot R_f$$

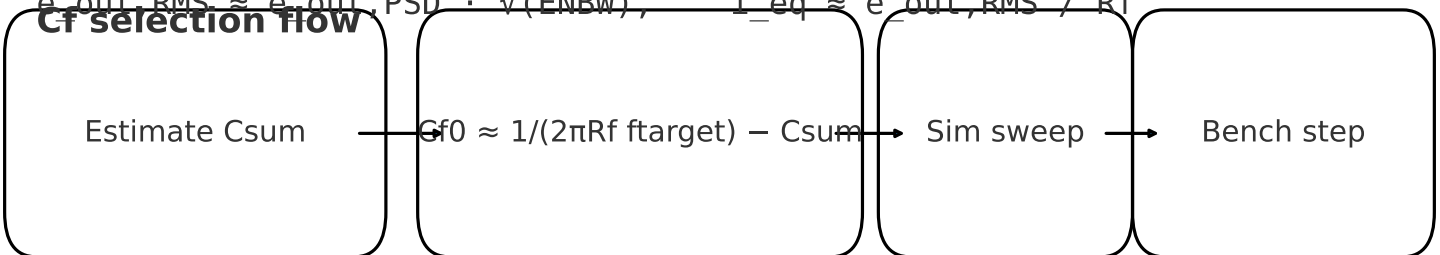
$$f_{-3dB} \approx 1 / (2\pi \cdot R_f \cdot C_{total}), \quad C_{total} \approx C_f + C_j + C_{in} + C_{stray}$$

$$ENBW \approx (\pi/2) \cdot f_{-3dB}$$

$$e_{out,PSD} \approx \sqrt{e_{Rf}^2 + e_i^2 + e_{shot}^2 + e_{en}^2}$$

$$e_{out,RMS} \approx e_{out,PSD} \cdot \sqrt{ENBW}, \quad i_{eq} \approx e_{out,RMS} / R_f$$

### Cf selection flow



## Worked example (first-cut)

Goal: 0–5 V ( $V_{ref}=2.5$  V),  $V_{head}=2$  V;  $I_{in}=10$  nA–50  $\mu$ A;  $f_{-3dB}\approx 200$  kHz

$$R_f \leq V_{head} / I_{max} = 2 \text{ V} / 50 \mu\text{A} = 40 \text{ k}\Omega \rightarrow \text{pick } 20 \text{ k}\Omega$$

$$C_{sum} \approx 20 \text{ pF} \rightarrow C_{f0} \approx 1 / (2\pi \cdot 20\text{k} \cdot 200\text{k}) - 20 \text{ pF} \approx 20 \text{ pF}$$

Place  $R_f/C_f$  tight to inverting pin; short loop      Guard ring at virtual ground /  $V_{ref}$

**Layout & debug (quick checks)**      PSD (example)  $e_{out,PSD} \approx 57 \text{ nV}/\sqrt{\text{Hz}}$ ;  $ENBW \approx 314$  kHz

$$e_{out,RMS} \approx 32 \mu\text{V}, \quad i_{eq} \approx 1.6 \text{ nA} \quad \rightarrow \quad DR \approx 90 \text{ dB}$$

Keep node away from clocks / dv/dt nets

Active probe / buffer for measurements

Step test: pick fastest stable  $C_f$

Recompute  $C_{sum}$  after protection changes