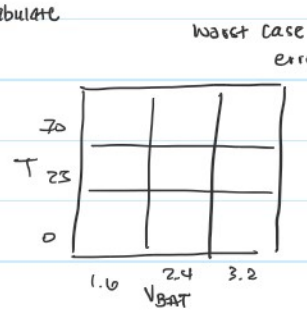
# 2019.12.06

Friday, December 6, 2019 11:07 AM

- Apple
- Projects
  - presentations
- Noise
- Research

- Make sure you're clear about your plots
  - what was the setup
- Good to tabulate




- Everything running
- $V_{in}$ = 0V to $\frac{1V}{PGA\ gain}$
- PGA gain = 1 to 8, inclusive

- 1st 10us free → $V_{BAT}$ = 0 - $V_{BAT}$ 100ns
- limited best-case
  - maybe some corners didn't turn out nicely

I) EE240B

- Razavi analysis of feedback
- Feedback analysis techniques
  - Return ratio ← control theory people like unidirectional
- Mismatch
- Fully differential
  - CMFB

II) Noise

- Environmental — not your problem { 60Hz (time of day); phase of the moon }
- Fundamental
  - shot

SHOT NOISE

$\overline{i_n^2} = 2q\overline{I}\Delta f$ ← $\Delta f$ [Hz]

  - thermal
    - equipartition theorem — All quadratic E storage elements have an average thermal energy $\frac{1}{2}k_BT$
      - capacitors $\frac{1}{2}CV^2$
      - inductors $\frac{1}{2}LI^2$
      - springs

$k_BT = (1.38 \cdot 10^{-23}\ \frac{J}{K})(300K)$

$\approx 4 \cdot 10^{-21}$ J

inductors

- springs

$\approx 4 \cdot 10^{-21}$ J

$= 4 \cdot 10^{-21} \frac{W}{Hz}$

$\frac{1}{2} C \overline{v_n^2} = \frac{1}{2} k_B T$

$\overline{v_n^2} = \frac{k_B T}{C}$ ← Voltage noise variance on a cap

@ $C = 1pF \rightarrow \sigma_{v_n} = 60\mu V$

° fluctuation/dissipation theorem – Every dissipative element causes fluctuation

- mechanical damper

- resistor

DISSIPATIVE ELEMENT NOISE POWER

$\overline{P_n} = 4 k_B T \Delta f \rightarrow P_{resistor} = \frac{V^2}{R} = I^2 R$

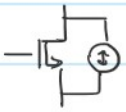
↳ $\overline{v_n^2} = 4 k_B T R \Delta f$

↳ $\overline{i_n^2} = \frac{4 k_B T}{R} \Delta f$

} @ $1k\Omega \rightarrow 4 \frac{nV}{\sqrt{Hz}}$

- transistors → BJT: shot noise

MOSFET:

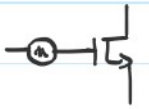


$\overline{i_n^2}$ {

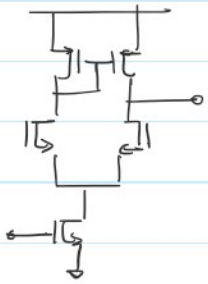
Subthreshold → $2q\bar{I}\Delta f$ (pn junction)

quadratic → $\frac{4 k_B T \Delta f}{R_{ch}}$ ← what is $R_{ch}$?

→ $4 k_B T \gamma g_m \Delta f$ ← $\gamma \approx \frac{2}{3}$

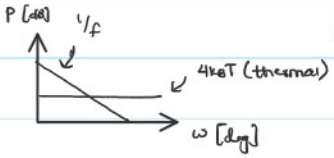


$\overline{v_n^2} = 4 k_B T \left( \frac{\gamma}{g_m} \right) \Delta f$



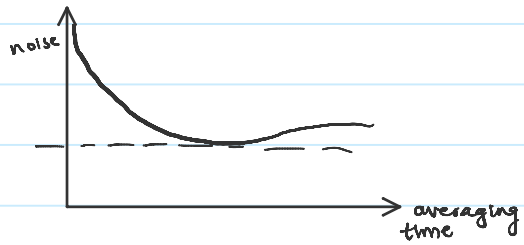
DON'T SWEAT THIS HERE

- flicker




← Low frequency SUUUCKS

Allan plot


noise
averaging time