Lecture 20 - Noise examples, cascades, quantization

**Excessed Noise Example**
- Noise Temp. vs. Voltage
- Build to Noises
- Attenuators
- SNR 0 dB in here

**Talking about noise**

- purely random corruption of signals (not many common misniers)
- so far we're focusing on thermal noise ... random e- fluctuation
- $\frac{kT}{w}$ of Aug $E$ of $kT$
- Gaussian
- $\frac{1}{w}$ noise is thermal it's distributed over wide $f$
- creating a power spectral density: noise power per $\Delta f$
- $P$ power = variance ... way of describing how wide noise is
- need language (for $E_n$)

$$P \rightarrow \frac{(X\sigma E_n)^2}{BPP} \rightarrow \frac{P}{BW} \rightarrow$$

- $\sigma E_n$ total noise power
- $\bar{V}_n = \sqrt{\sigma E_n}$ is std. dev of noise
- Affected by $BW$, so hard to add up.

- one crucial metric we haven't covered is signal-noise ratio (SNR)

$$\frac{P}{\sigma E_n^2}$$

- used in a figure of merit for amplifiers can noise typer/factor

- noise factor $n_s = \frac{SNR_i}{SNR}$ is always $\geq 1$
- noise figure $NF = 10 \log n_s$
Let's look at a typical noise example

\[ T_0 = \frac{1}{4 \sqrt{\text{B}_{	ext{in}}}} \]

- **Input**
  - \( V_{\text{in}} = -50 \text{dBm} \)

- **k**: amplifier gain

- **T**: switch
  - \( T_{\text{ref}} \)

- **Gain**:
  - LNA: \( G \) dB

- **Sections**
  - Attenuator: \( T = 10^{-\frac{3}{2}} \) dB
  - \( T = 10^{-\frac{3}{2}} \cdot T \)

- **Gain Bandwidth Product**
  - \( G \cdot \text{BW} = 100 \text{Hz} \)

- **Noise Sources**
  - \( N_{\text{in}}^2 = V_{\text{in}}^2 \)
  - \( N_{\text{out}}^2 = V_{\text{out}}^2 \)

- **Power Gain**
  - \( P = \frac{V_{\text{out}}^2}{V_{\text{in}}^2} \)

- **Noise Density**
  - \( B_{\text{in}} = 1 \text{MHz} \)

- **Noise Temp**
  - \( \text{SNR} = \frac{V_{\text{in}}^2}{T_0 \cdot k \cdot B_{\text{in}}} \) (assuming no resistors or gain)

- **Noise加 at each stage**
  - Stage 1:
    - \( -50 \text{dBm} \)
    - \( N_{\text{in}}^2 \)
    - \( \approx 290 \)
    - \( B_{\text{in}} = 1 \text{kHz} \)

  - Stage 2:
    - \( -51 \text{dBm} \)
    - \( \text{IL} \cdot N_{\text{in}}^2 + N_{\text{out}}^2 \)
    - \( = 254.5 \)
    - \( 10 \cdot (254.5) + 38 \)
    - \( 2603 \)

  - Stage 3:
    - \( -41 \text{dBm} \)
    - \( G(\text{IL} \cdot N_{\text{in}}^2 + N_{\text{out}}^2) + N_{\text{out}}^2 \)
    - \( 2603 \cdot 0.5 + 290 \)
    - \( 1591.5 \)
    - \( 3000 \cdot 1591.5 \)

  - Stage 4:
    - \( -44 \text{dBm} \)
    - \( \text{SNR} \)
    - \( 1.8 \times 10^6 \)
    - \( 1.8 \times 10^6 \)

  - Stage 5:
    - \( -16 \text{dBm} \)
    - \( 1.59 \times 10^6 \cdot 0.63 + 170 \)
    - \( 1.00 \text{e}^6 \)
    - \( 1.8 \times 10^6 \)

- Joint noise
  - \( e^{-1} = 1 + T_{\text{ref}} \)

- Noise at end matters much less!

- Capture by "rehearing" noise
- Anything in the near field can capacitively load an antenna
  - adds cap load & changes effective length

- Antenna is a lumped element.

- \( L \) drive \( V \) ideal voltage src is possible
  - \( L \) is in L law here, adds src impedance

- \( L = C \) of antenna related to velocity \( v = \lambda / 2 \) ... capacitance \& inductance/length

- \( L \) and \( \frac{i}{\sqrt{L C}} \) tell you resonant freq of antenna

- \( L \) so \( \frac{i}{\sqrt{L C}} \approx v_0 \) \( \Rightarrow \)
  - \( C = \frac{2\pi \lambda}{2\pi} = \frac{c}{\sqrt{L C}} \)
  - \( \lambda = \frac{1}{\sqrt{L C}} \)