Noise Power, Noise Figure and Noise Temperature

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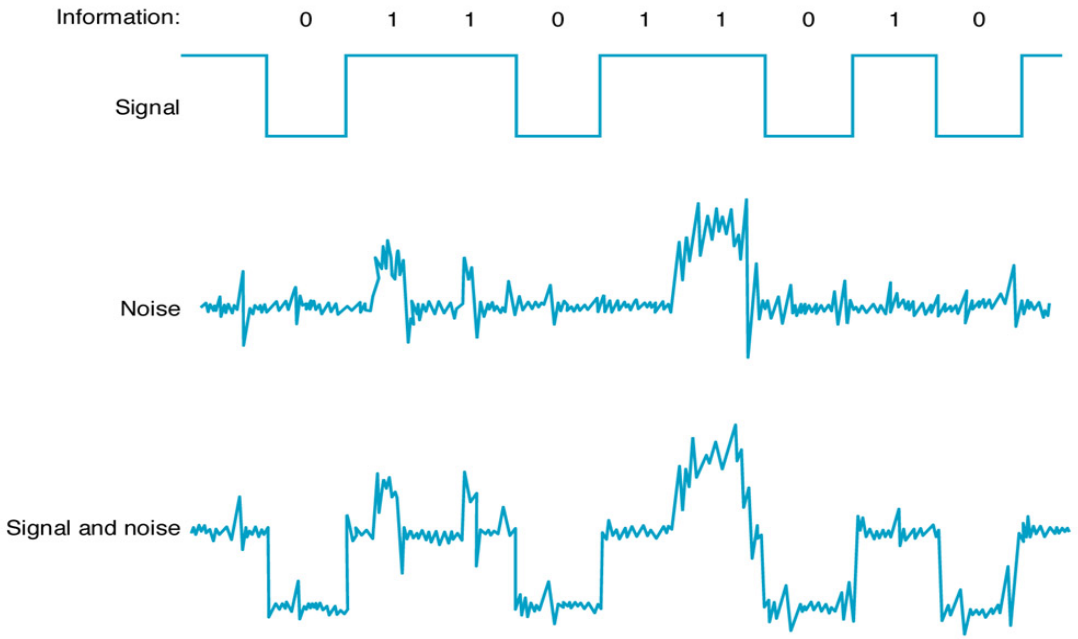
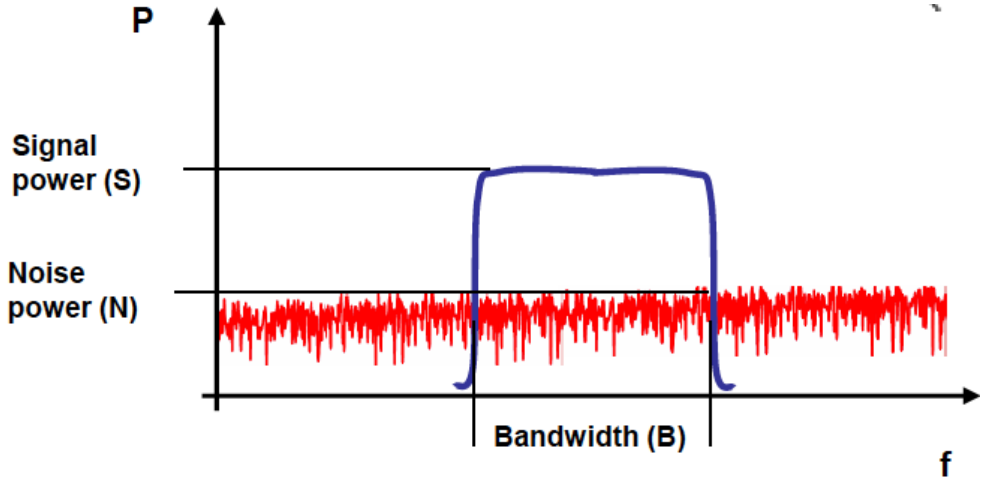
Sujeong Lee

Noise

- “Any unwanted input” - UNDESIRABLE portion of an electrical signal
- Limits systems ability to process weak signals



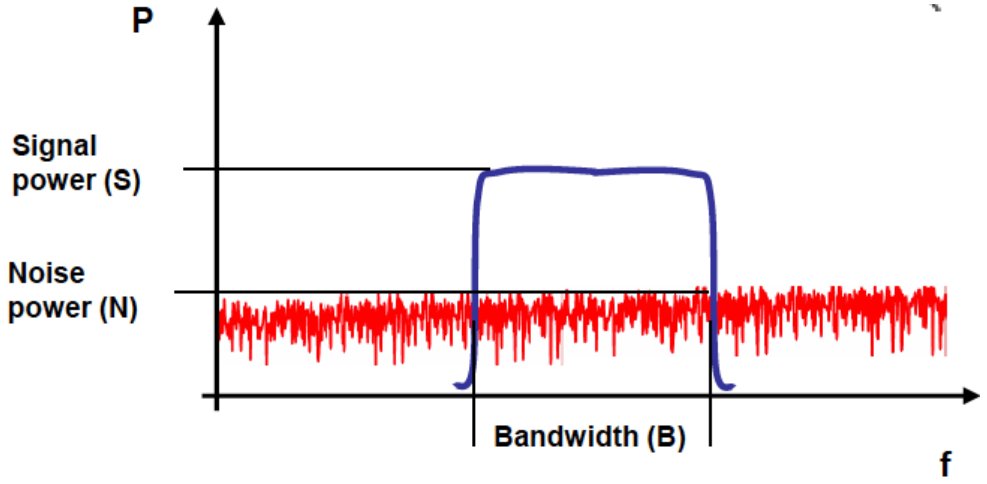
Noise Power



- Most of input noise = Thermal Noise
- Noise power $N_p = k_B T B$

  k_B = Boltzmann's constant 1.38×10^{-23} J/K
  T = Absolute temperature of device
  B = Circuit bandwidth

Noise Power

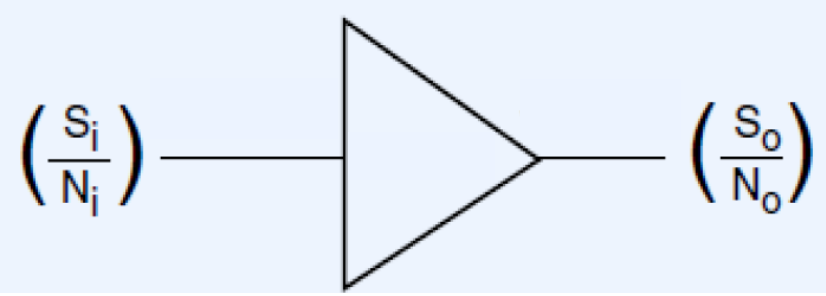


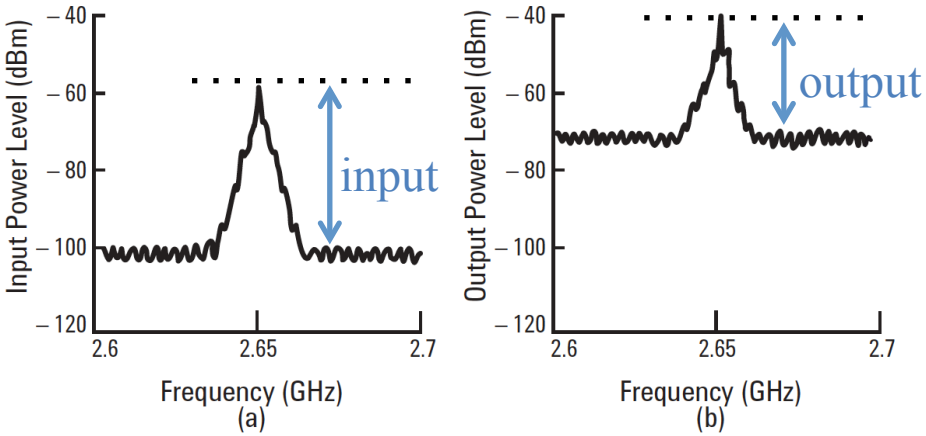
- Signal to Noise Ratio (SNR)

$$SNR = \frac{S(f)}{N(f)} = \frac{average - signal - power}{average - noise - power}$$

Noise Figure

- Noise Figure





- Noise figure represents the degradation in signal/noise ratio as the signal passes through a device.

$$F = \frac{S_i/N_i}{S_o/N_o}$$

- F is always greater than 1.

Noise Figure

- Noise Figure

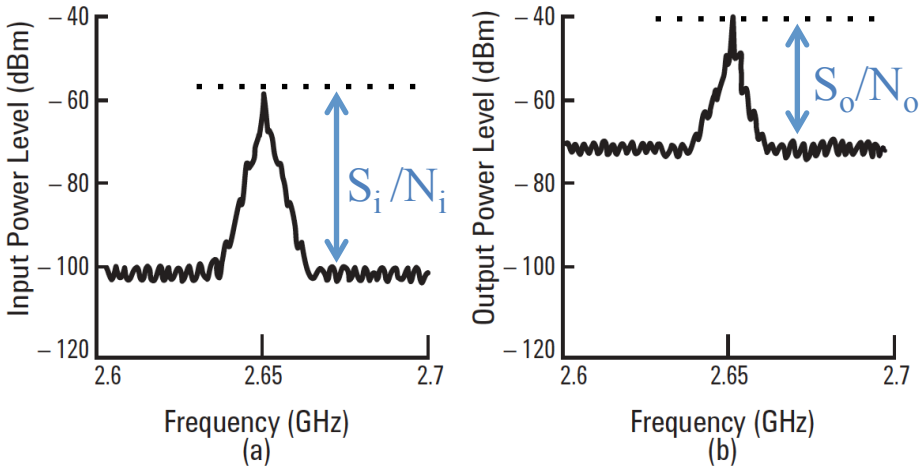
Noise Factor

$$F = \frac{S_i/N_i}{S_o/N_o}$$

Modern usage of "noise figure" usually is reserved for the quantity NF, expressed in dB units:

$$NF = 10 \log_{10} F \quad [dB]$$

$$\mathbf{NF = (Si/Ni)_{dB} - (So/No)_{dB}}$$



$(Si/Ni)_{dB} = 40$ dB

$(So/No)_{dB} = 30$ dB

Noise Figure = 10 dB

Noise Temperature

- Comes from the random motion of electrons
  → Thermal Noise
- Convenient! Common basis for measuring random electrical noise from any source

- Relation with Noise Figure

$$T_e = T_o (F - 1)$$

T_e : The effective noise temperature of device

T_0 : a reference temperature 290K (room temperature)

Summary

- Noise Power
  - The magnitude of Noise $N_p = k_B T B$
- Noise Figure
  - Noise Factor $F = \frac{S_i/N_i}{S_o/N_o}$
  - Noise Figure : the degradation of SNR

$$NF = 10 \log_{10} F \ \ [dB]$$

- Noise Temperature
  - Basic tool of measuring any kind of noise
  - Relation with Noise Factor $T_e = T_o (F - 1)$