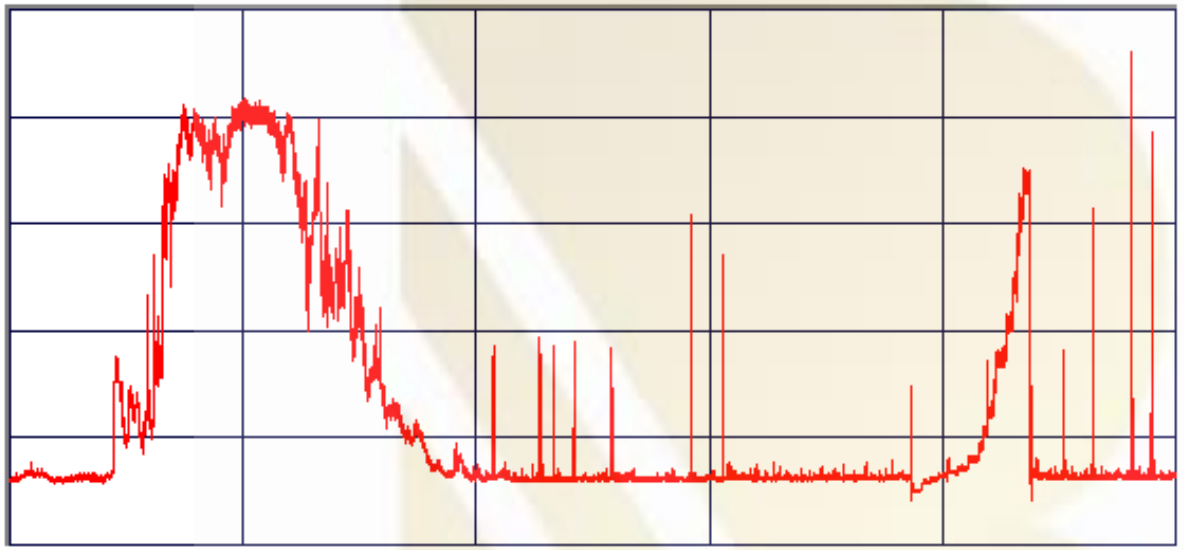


Topic 1 - RF Components and Basic Concepts

1.2 - Noise

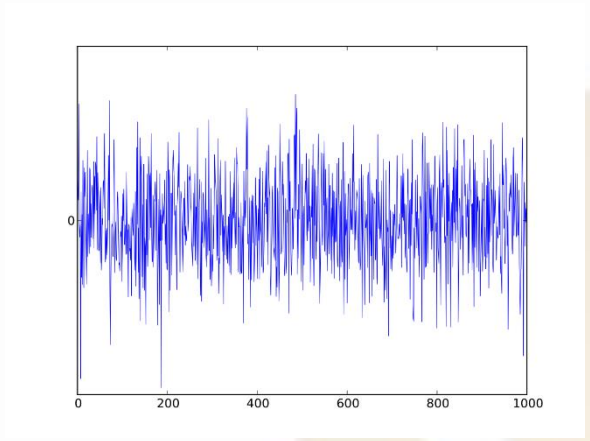
Noise

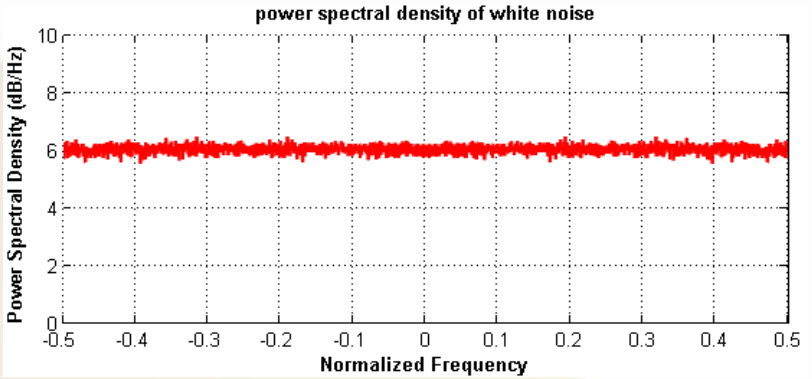
- Noise is **random**. It extends in various forms across the frequency spectrum, although not always in the same amplitude. Accordingly there are different categories of noise according to the frequency distribution:

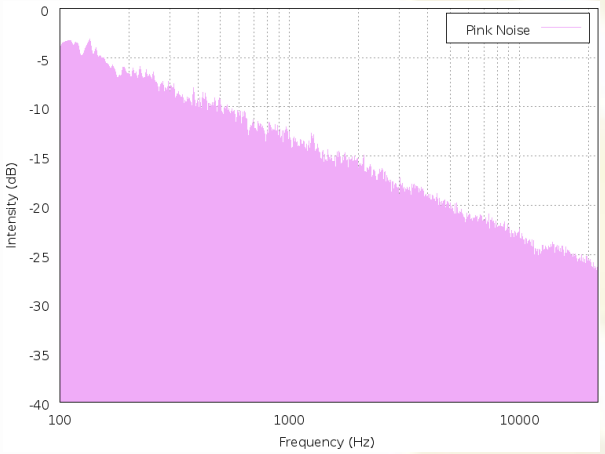
❖ ***White noise:*** White noise is the type of noise that affects all frequencies equally. It spreads up from zero frequency upwards with a flat amplitude.

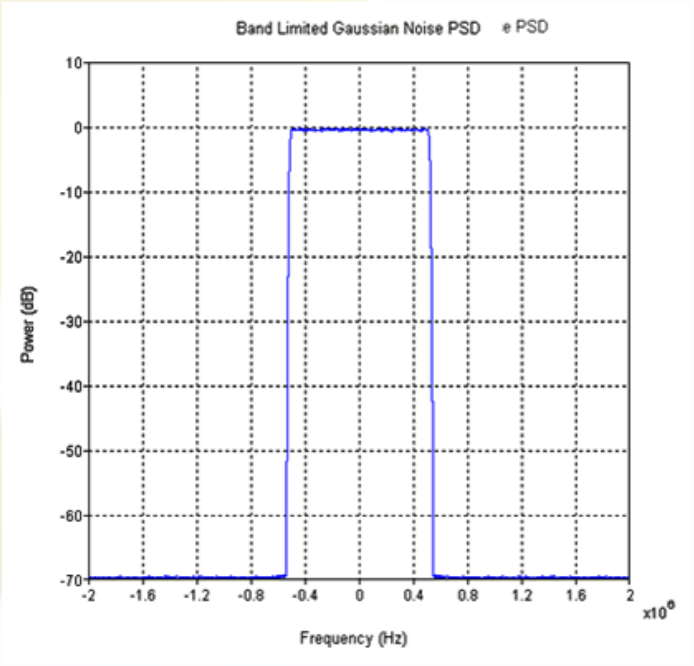
❖ ***Pink noise:*** Pink noise does not have a flat response. Its power density falls with increasing frequency.

❖ ***Band limited noise:*** Noise can have its frequency band limited either by filters or the circuit through which it passes.


0
0
200
400
600
800
1000

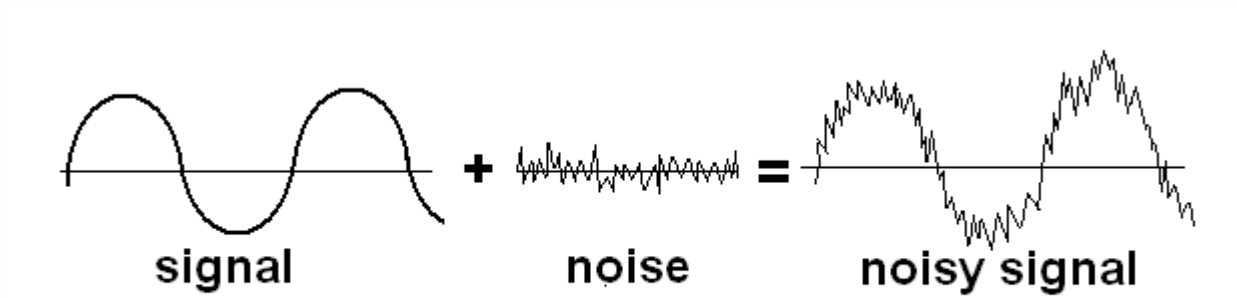

power spectral density of white noise
Power Spectral Density (dB/Hz)
10
8
6
4
2
0
-0.5
-0.4
-0.3
-0.2
-0.1
0
0.1
0.2
0.3
0.4
0.5
Normalized Frequency

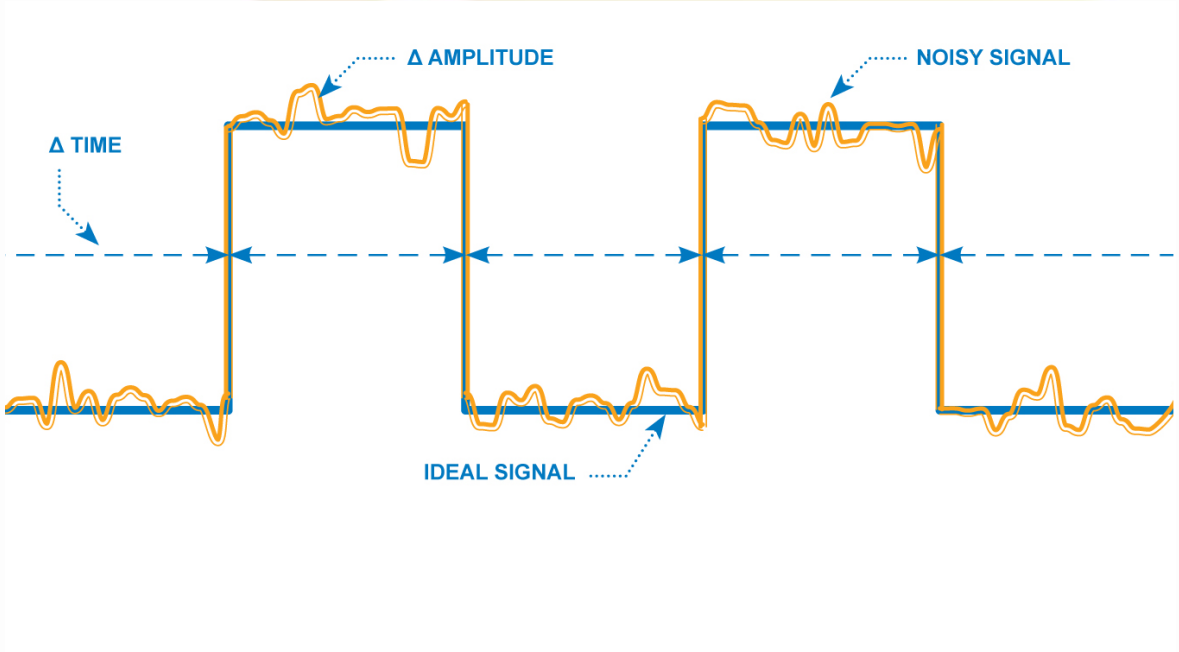

Pink Noise
Intensity (dB)
0
-5
-10
-15
-20
-25
-30
-35
-40
100
1000
10000
Frequency (Hz)

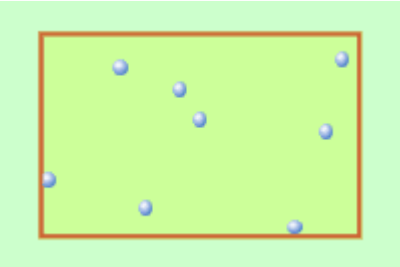

Band Limited Gaussian Noise PSD
e PSD
Power (dB)
10
0
-10
-20
-30
-40
-50
-60
-70
-2
-1.6
-1.2
-0.8
-0.4
0
0.4
0.8
1.2
1.6
2
x10^6
Frequency (Hz)

Effect of Noise

- Variations in amplitude caused by noise can mask out a signal, or it can cause data errors, increasing the bit error rate.
- For the best performance, obviously the signal should be as clear of the noise as possible.
- In many instances, there is an acceptable level of data errors or signal to noise ratio against the cost involved.

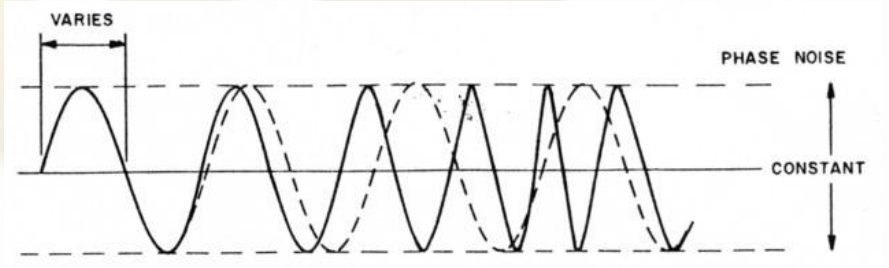

signal
noise
noisy signal


Δ AMPLITUDE
NOISY SIGNAL
Δ TIME
IDEAL SIGNAL



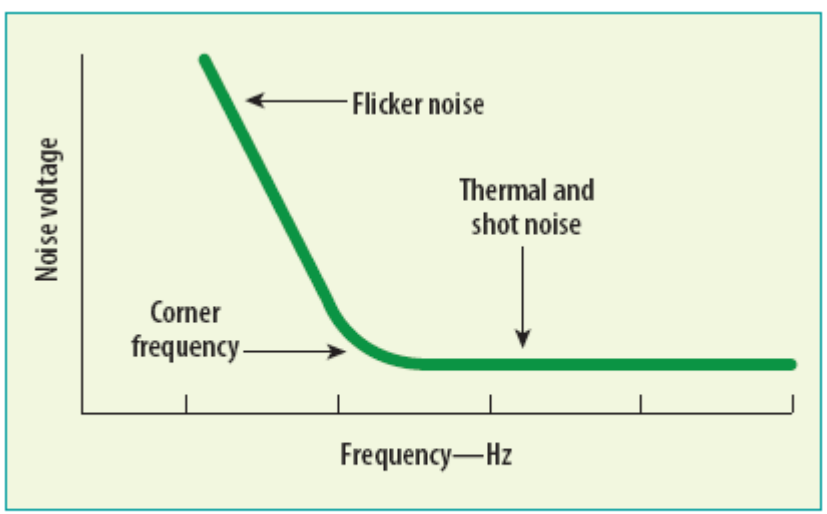
Different types of Noise

- Thermal noise: Thermal agitation of charge carriers - typically electrons - in a conductor
- Shot noise: This form of noise that arises from the time-dependent fluctuations in electrical current. (Originates from the discrete nature of electric charge.)
- Phase noise: Phase noise is a form of RF noise that is visible on radio frequency, and other signals. It appears in the form of phase jitter or perturbations on the signal.



Different types of Noise

- Flicker noise, 1/f noi…tually all electronic components.
- Flicker noise is propo… frequency.
- It can show up as a v…ccurs as a resistance fluctuation.



Flicker noise is low-level semiconductor device noise that increases as a function of inverse carrier frequency, or 1/f.

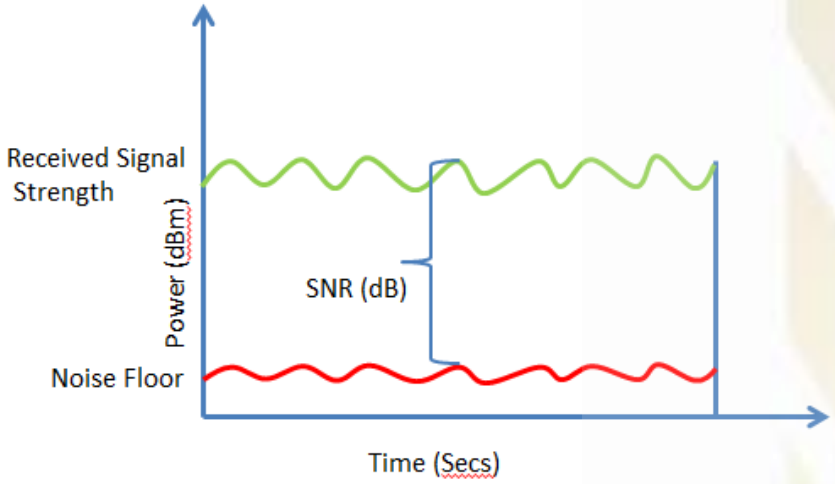
- Avalanch noise: Avalanche noise is a form of noise that occurs in pn junctions that are operated in a region at or close to the point of avalanche breakdown.

Signal-to-noise ratio

- Signal-to-noise ratio: (SNR) is a measure used in science and engineering that compares the level of a desired signal to the level of background noise.
- It is defined as the ratio of signal power to the noise power, often expressed in decibels.

$$\mathrm{SNR} = \frac{P_{\text{signal}}}{P_{\text{noise}}} \qquad \mathrm{SNR}_{\text{dB}} = 10 \log_{10} \left(\frac{P_{\text{signal}}}{P_{\text{noise}}} \right)$$

Example



Ps=1mW
Pn=0.1mW

SNR and SNR(dB) ???