# IMPERFECT SAMPLING

What is the impact of errors and rounding?

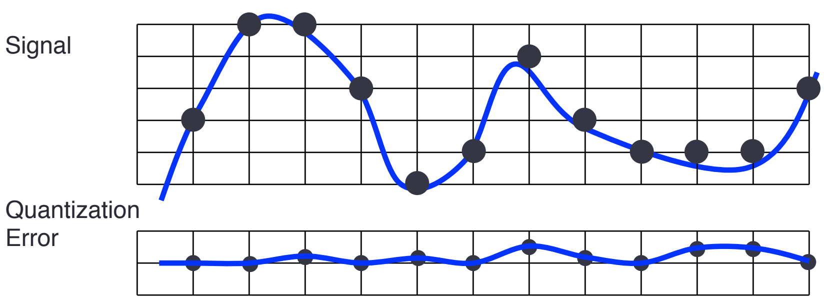




## How to Describe Noise

- Since absolute levels rarely exist, measure RATIO of Signal to Noise.
- Since signal level is variable, measure MAXIMUM Signal to Noise.
- Units: dB = decibel
  10dB = ×10 power
  20dB = ×100 power = ×10 amplitude
  6dB = ×2 amplitude

# Quantization Noise




*To simplify analysis, assume quantization error is uniformly randomly distributed in [-0.5, +0.5]*





# Quantization Examples

| | Sine Tone | Cello |
|---|---|---|
| 16-bit | | |
| 8-bit | | |
| 4-bit | | |
| 2-bit | | |

## Quantization Noise, M bits/sample

What's the effect of **rounding** to the nearest integer sample value?





## Quantization Noise, M bits/sample

- Rounding effects can be approximated by adding white noise (uniform random samples) of maximum amplitude of ½ least significant bit.

$$\textbf{SNR(dB)} = \textbf{6.02M} + \textbf{1.76}$$

**(about 6dB/bit)**

## Noise

How many **bits per sample** should we use? Why does it matter?





## Noise

The signal-to-noise ratio is determined by the bits per sample!

## Can Discrete Samples Really Capture a Continuous Signal?

**DISCRETE SAMPLES CAN CAPTURE A CONTINUOUS BAND-LIMITED SIGNAL *WITHOUT LOSS***

- Band-limited signal ➡ no lost frequencies!
- To the extent you can do perfect sampling ➡ no noise!

## Summary

- Theoretical result: discrete samples can capture *all* information in a band-limited signal!
- Practical result 1: sampling limits bandwidth to 1/2 sampling rate (the Nyquist frequency)
- Practical result 2: sampling adds quantization noise; SNR is about 6dB per bit
- What's a decibel?