Introduction to noise in ADC systems

TI Precision Labs – ADCs

Created by Chris Hall & Bryan Lizon

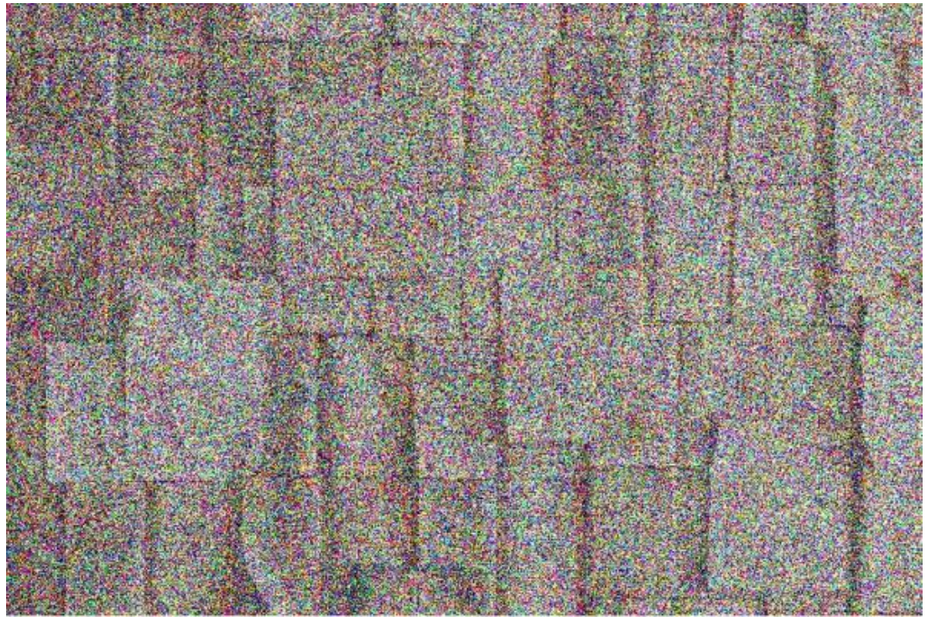
Presented by Alex Smith

ADC noise topics

- Introduction to noise in data acquisition systems
- ADC noise types
- Measuring and specifying ADC noise
- Defining system noise performance for low-speed delta-sigma ADCs
- Understanding effective noise bandwidth
- How gain affects ADC noise and dynamic range
- Do you need an amplifier for your high-resolution ADC?
- How reference noise affects ADC noise performance
- Reference noise reduction methods

Noise example

High-Resolution Image



Noisy Image

Photo by Patrick Thomas via https://unsplash.com/photos/Oaqk7qqNh_c

WHAT is noise & WHY is it important?

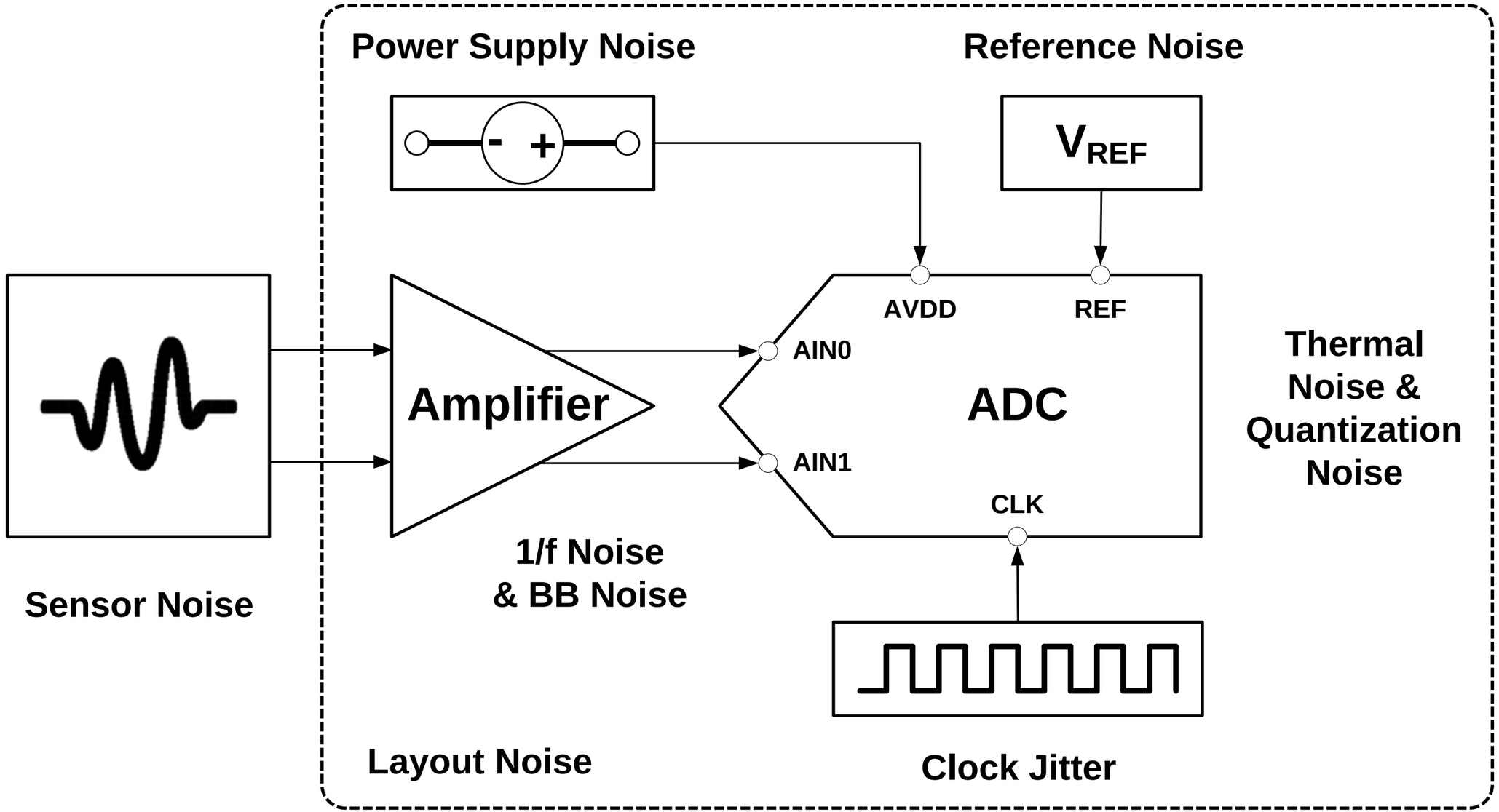
WHAT?

Any unwanted signal that distorts or interferes with the desired signal, causing it to deviate from its original value.

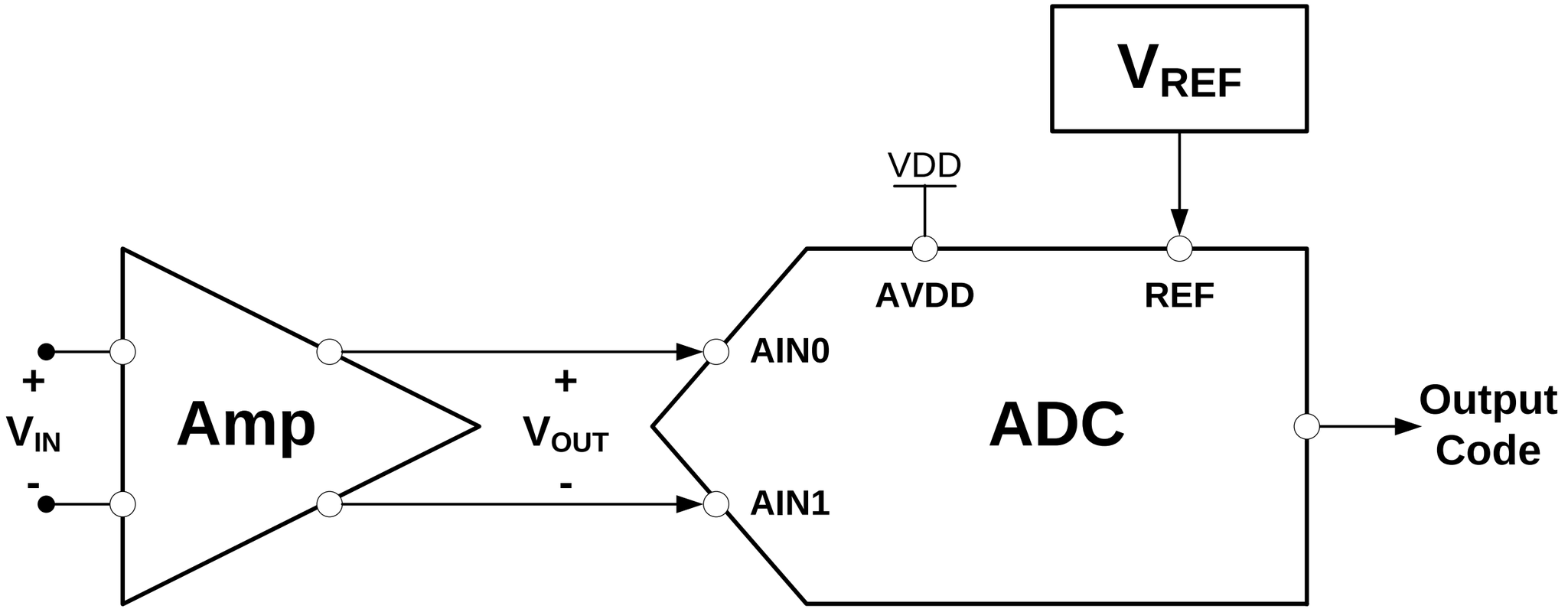
WHY?

- Noise limits the smallest signal you can resolve
- Noise is a system-level design consideration
- Noise affects overall system accuracy

WHERE does noise come from?

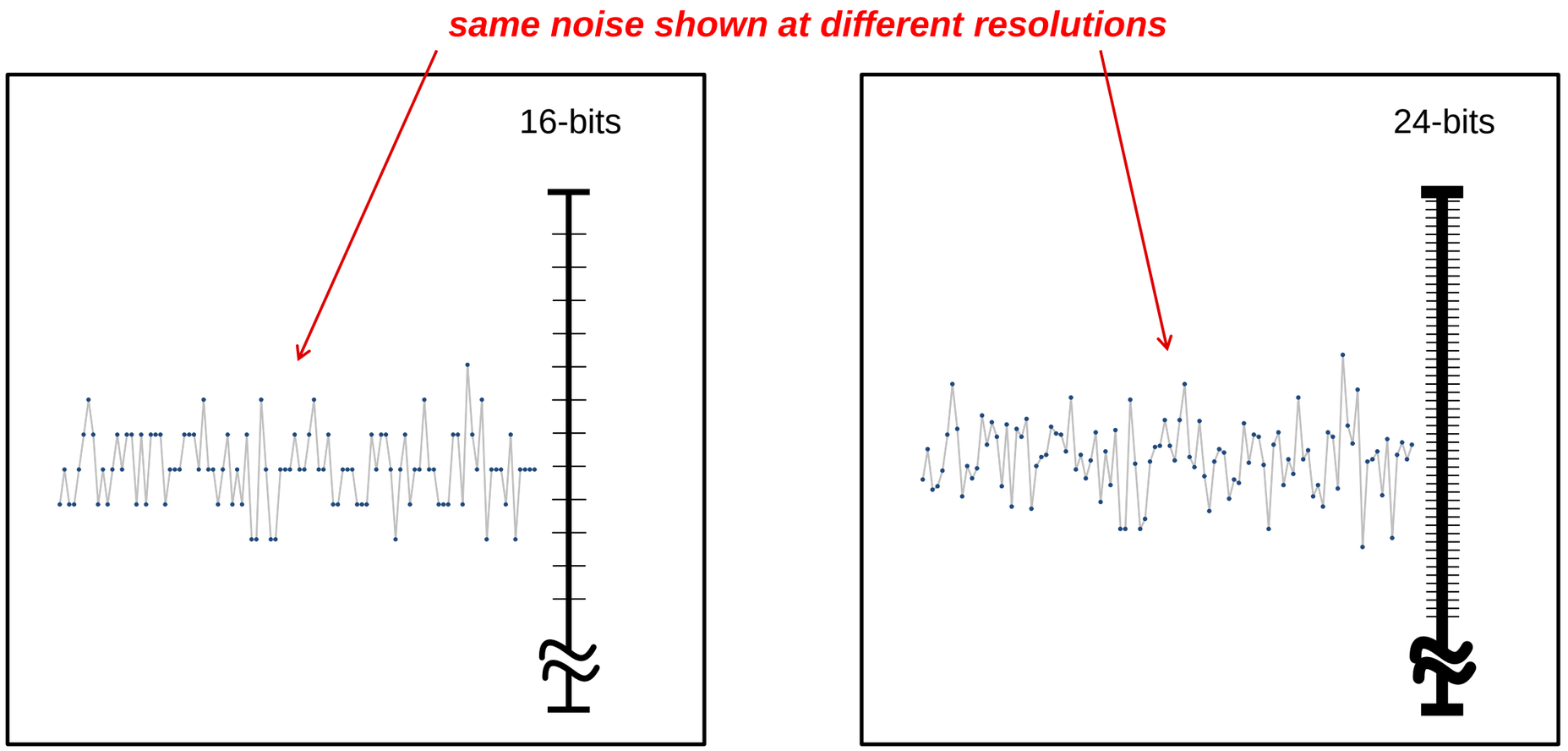


The goal of this Precision Labs series



More bits ≠ higher resolution

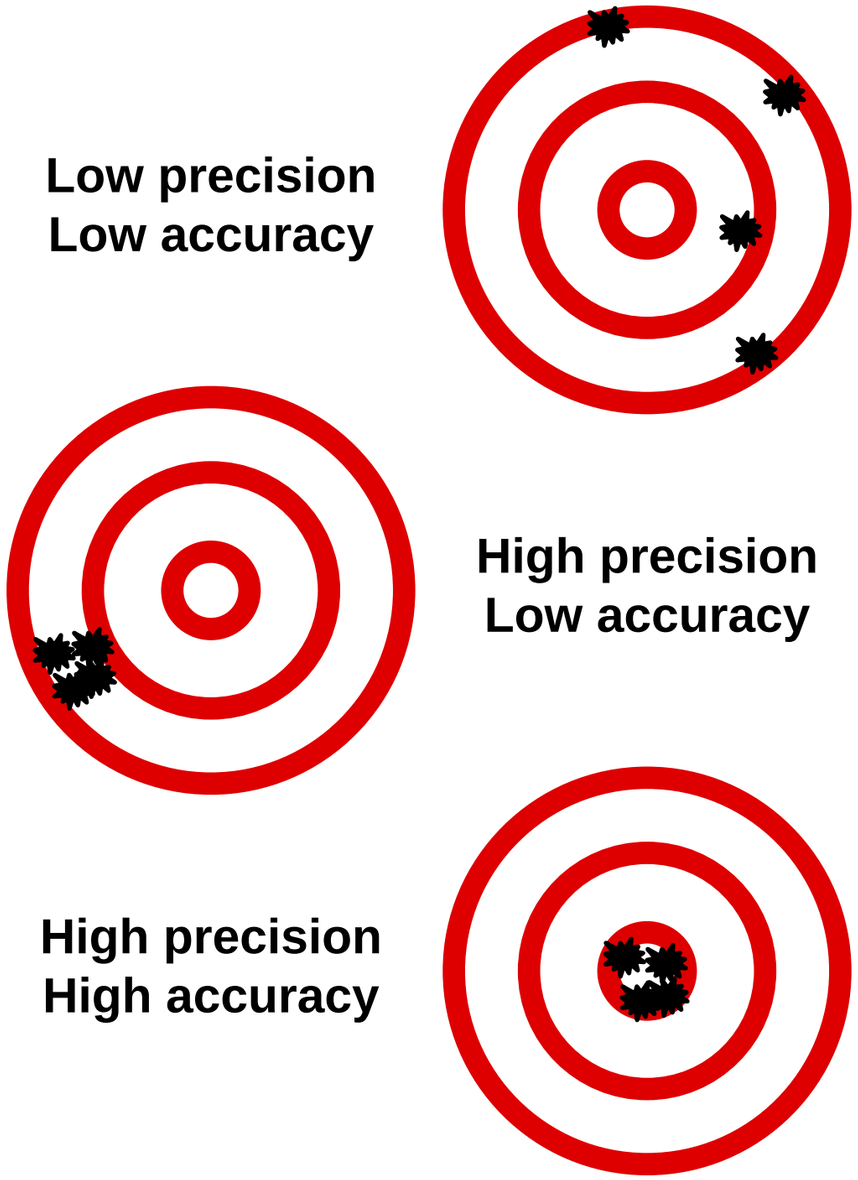
To increase precision, consider the overall **system's** noise contribution, not just the ADC's resolution



Precision versus accuracy

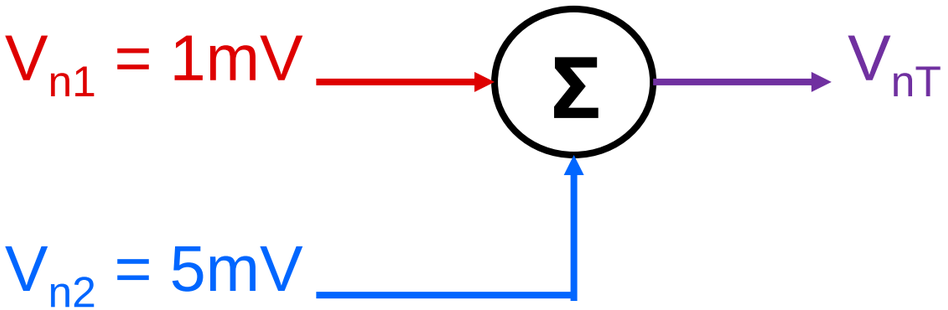
Precision = ability of the ADC to provide repeatable results (“resolution”)

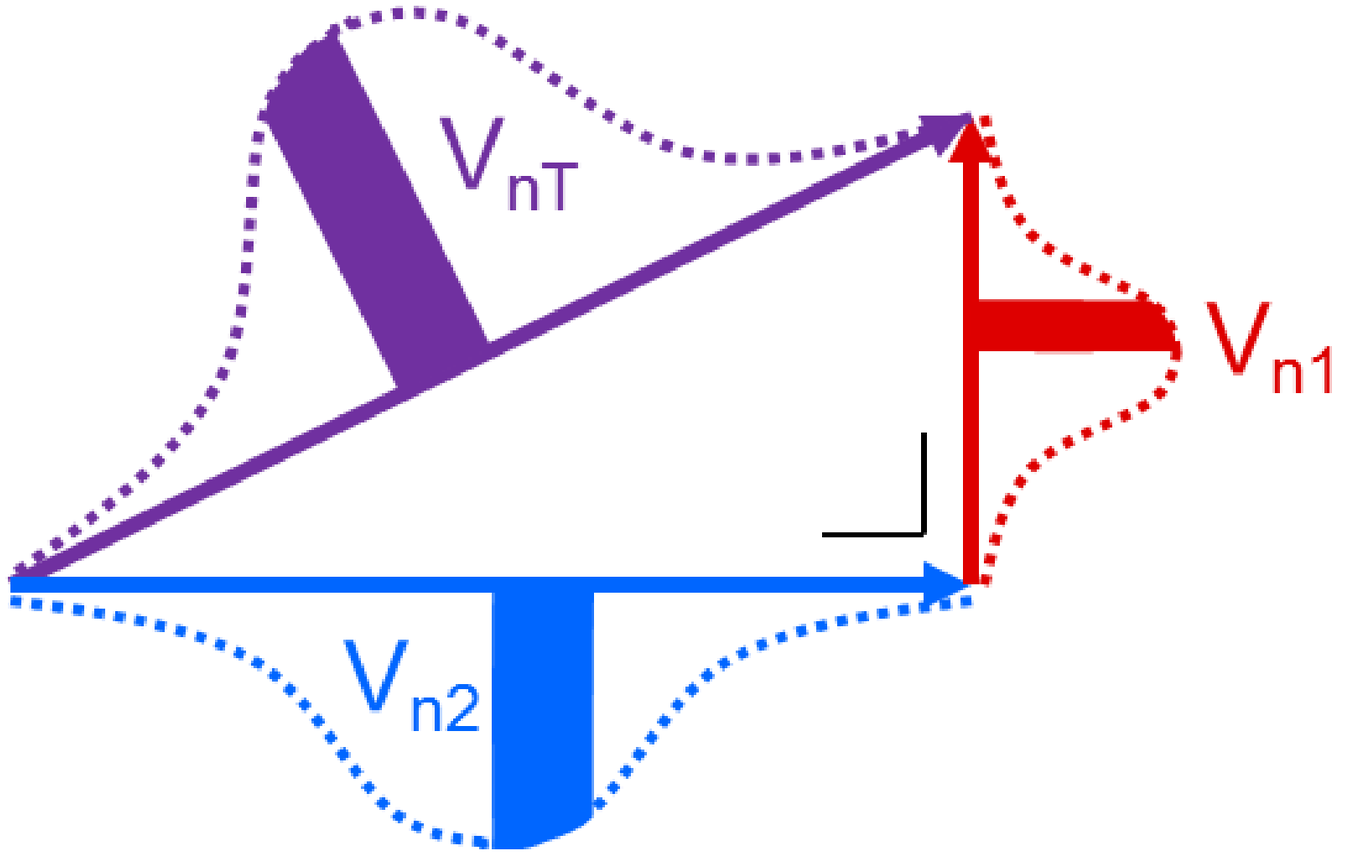
Accuracy = how closely the ADC’s digital output corresponds to the analog input signal



Vector addition for uncorrelated errors

$$V_{nT} = \sqrt{V_{n1}^{\,2} + V_{n2}^{\,2}}$$





$$V_{nT} = \sqrt{1^2 + 5^2}$$

$$V_{nT} = 5.1mV_{RMS}$$

Only 2% increase in noise!

Thanks for your time!
Please try the quiz.

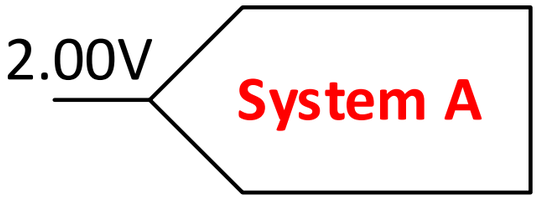
Quiz: Introduction to noise in data acquisition systems

1. (T/F) Changing from a 20 bit converter to a 24 bit converter may ***NOT*** actually increase your systems resolution if the noise is too large.
   a. True.
   b. False.

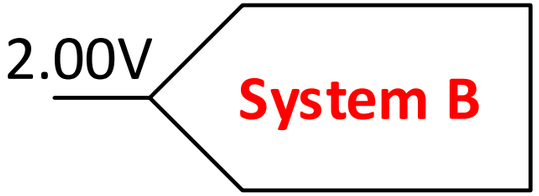
Quiz: Introduction to noise in data acquisition systems

2. An input signal of 2V is applied to three different ADC systems. Which system has good precision but poor accuracy?

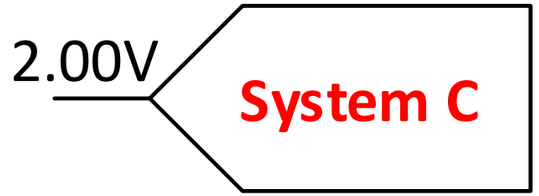
   a. System A
   b. System B
   c. System C



2.00, 2.01, 1.99, 2.00, 2.02, 1.98



2.10, 2.11, 2.09, 2.10, 2.12, 2.08

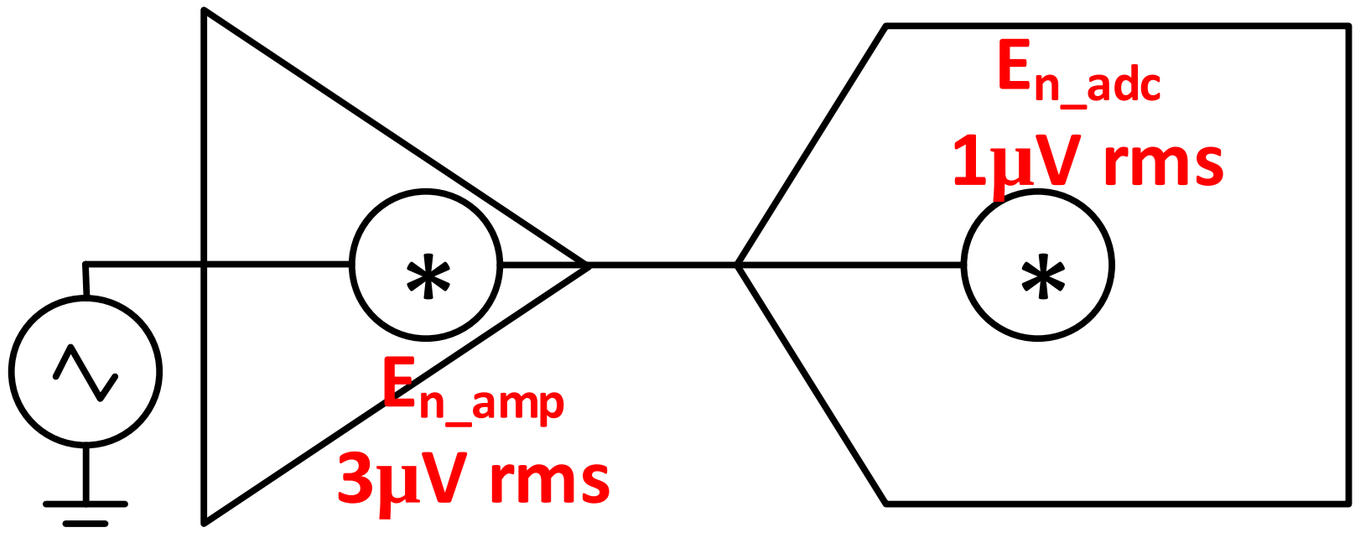


2.20, 2.11, 1.89, 2.03, 2.12, 1.93

Quiz: Introduction to noise in data acquisition systems

3. For the circuit below the amplifier and ADC noise will add together. What is the total noise.
   a. 3.00µV
   b. 3.16µV
   c. 3.22µV
   d. 4.00µV

$$E_{nTotal} = \sqrt{(3\mu V)^2 + (1\mu V)^2} = 3.16\mu V$$



Thanks for your time!