Statistics Behind Error Analysis

TIPL 4201
TI Precision Labs – ADCs

Created by Art Kay

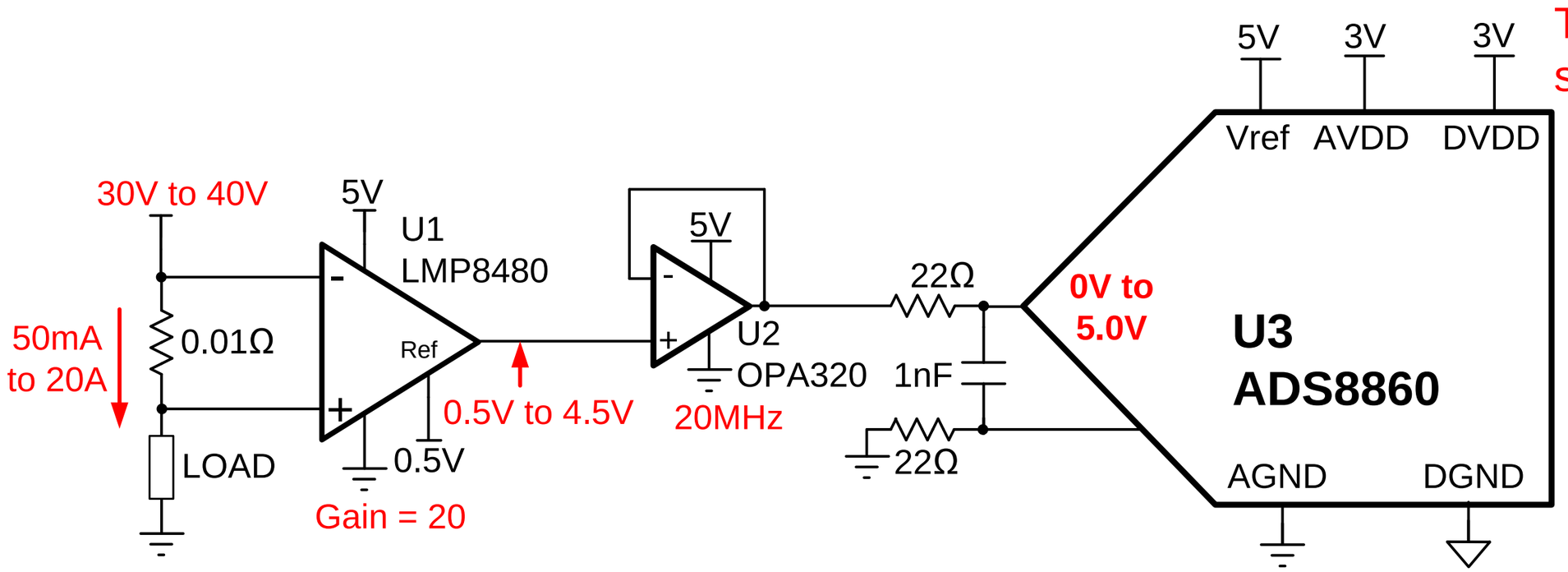
Presented by Peggy Liska

Find the worst case offset

Device	PARAMETER	MIN	TYP	MAX	UNITS
LMP8481	V_{OS} Offset Error	-265	±80	+265	µV
OPA320	V_{OS} Offset Error	-150	±40	+150	µV
ADS8860	E_O Offset Error	-4	±1	+4	mV

Worst case offset at ADS Input
$V_{osT} = Gain \cdot V_{U1} + V_{U2} + V_{U3}$
$V_{osT} = 20 \cdot (265\mu V) + (150\mu V) + (4mV)$
$V_{osT} = 9.27mV$

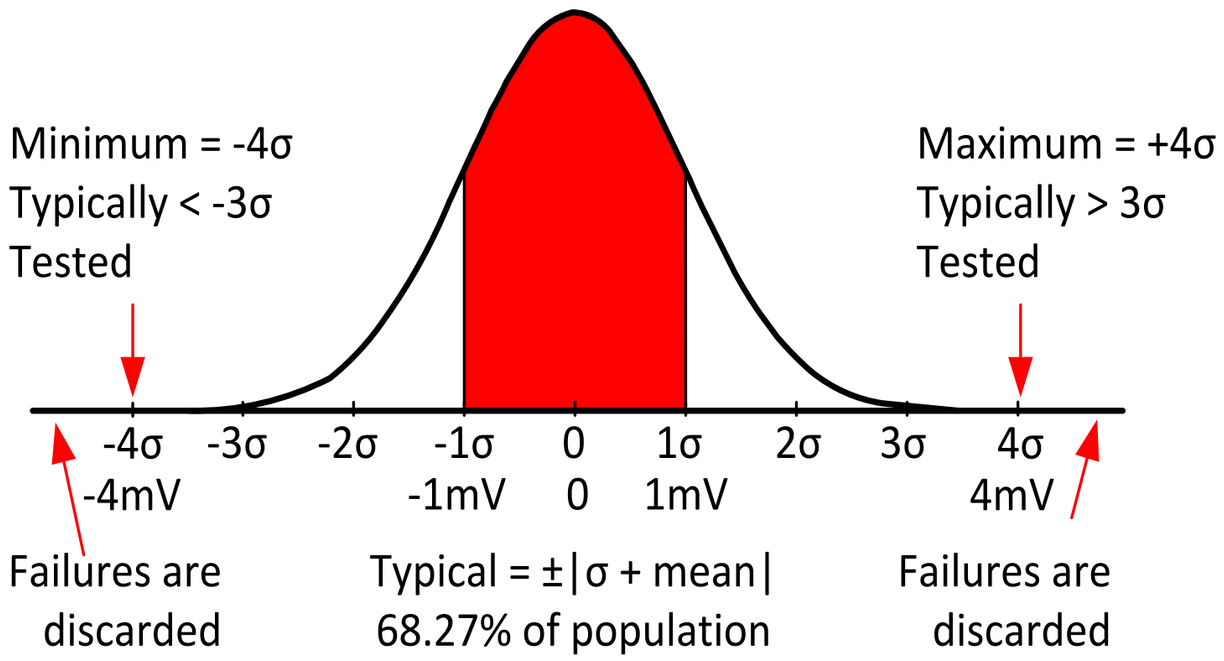
This result may be statistically unrealistic



Statistics Behind Typical and Maximum

PARAMETER ADS8860		MIN	TYP	MAX	UNITS
E_O	Offset Error	-4	±1	+4	mV
E_G	Gain Error	-0.01	±0.005	+0.01	%FSR

Gaussian Distribution



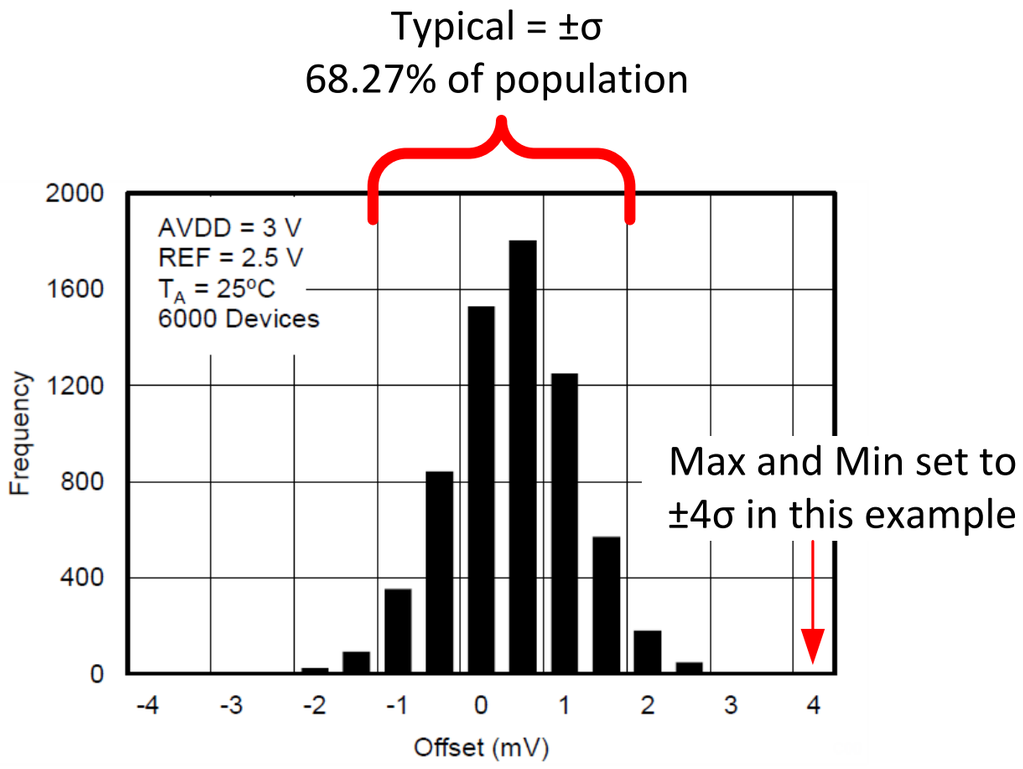


Figure 41. TYPICAL DISTRIBUTION OF OFFSET ERROR

Probability that we are near worst case

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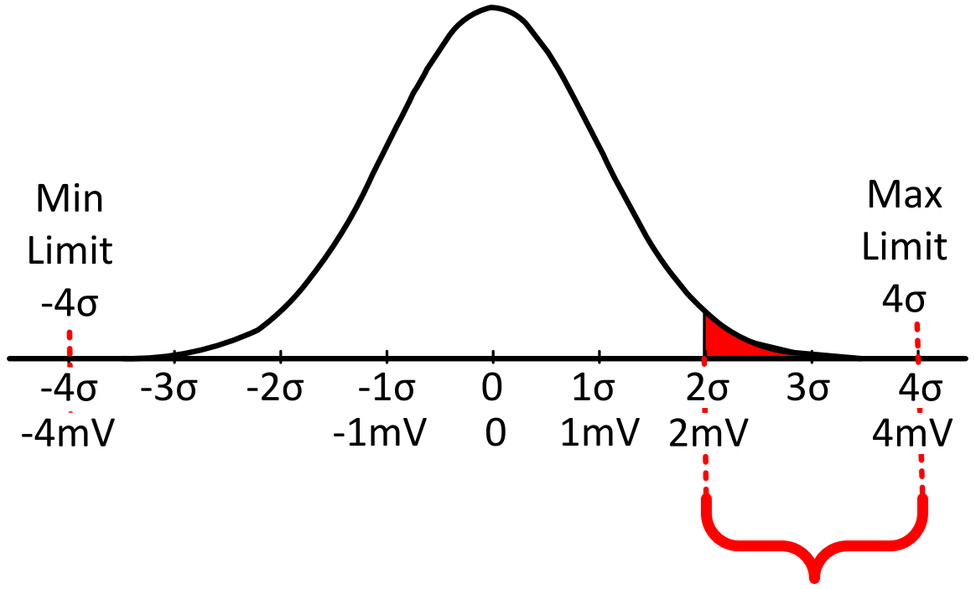
E_O	Offset Error	-4	±1	+4	mV
E_G	Gain Error	-0.01	±0.005	+0.01	%FSR

ADS8860 Offset



2mV < Offset < 4mV
Probability = P(C) = 2.272%

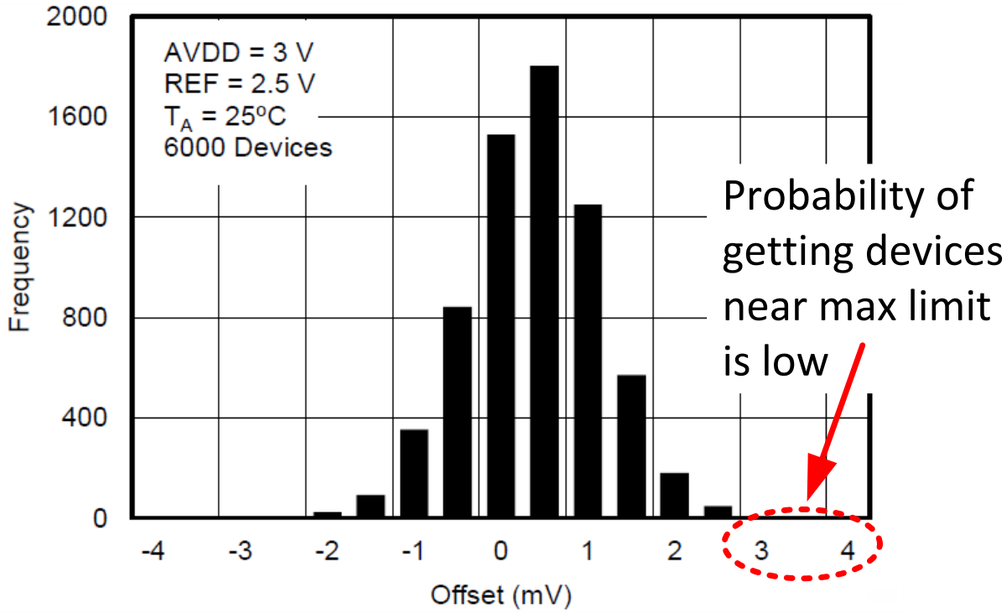
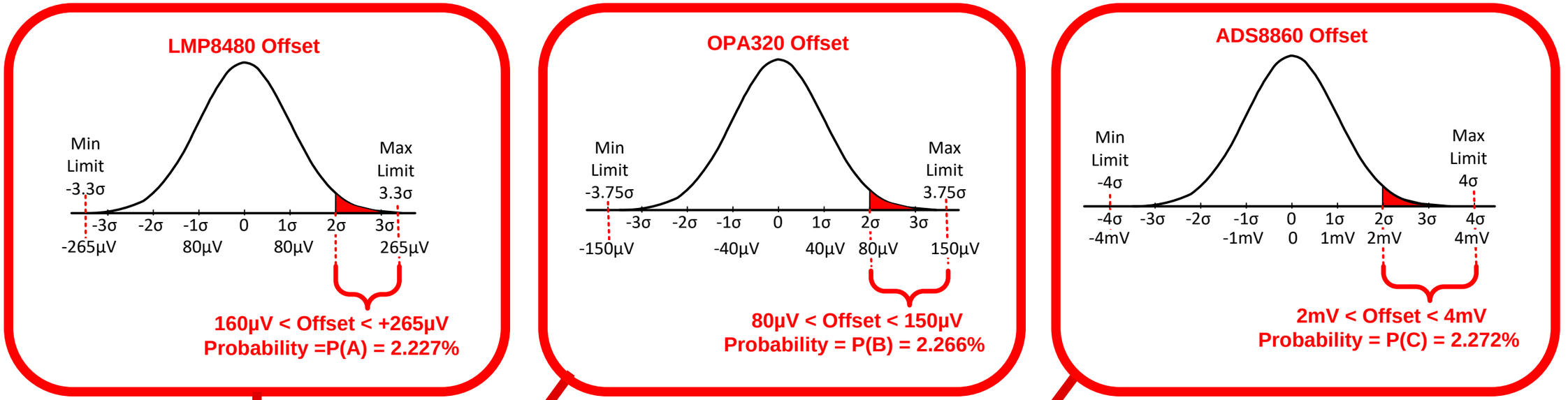
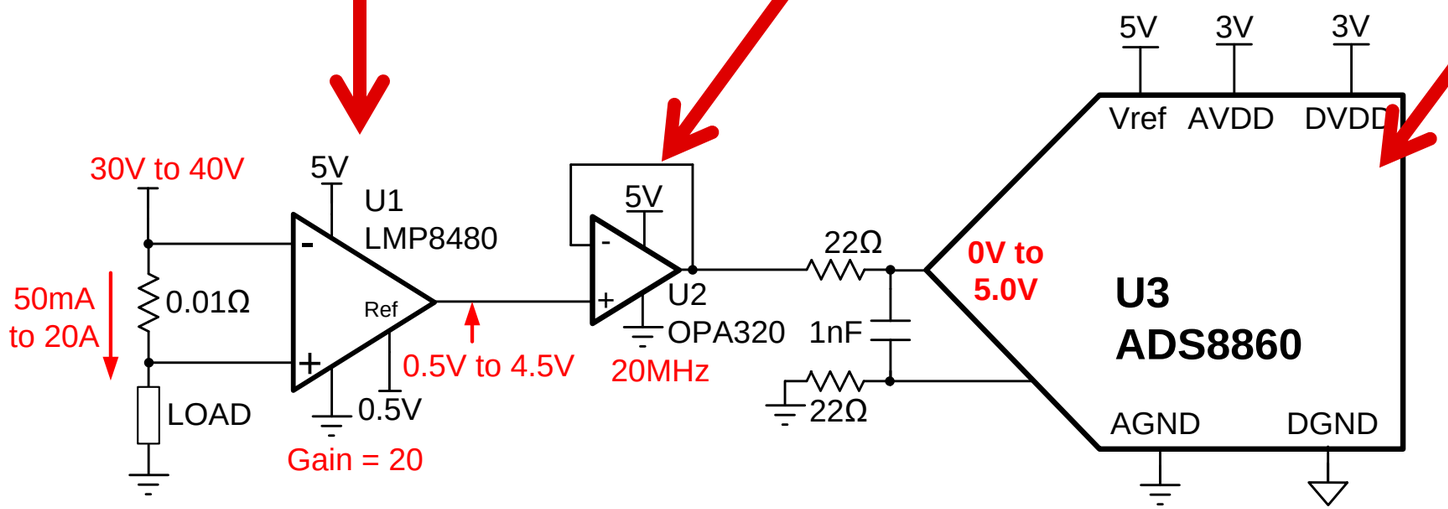


Figure 41. TYPICAL DISTRIBUTION OF OFFSET ERROR

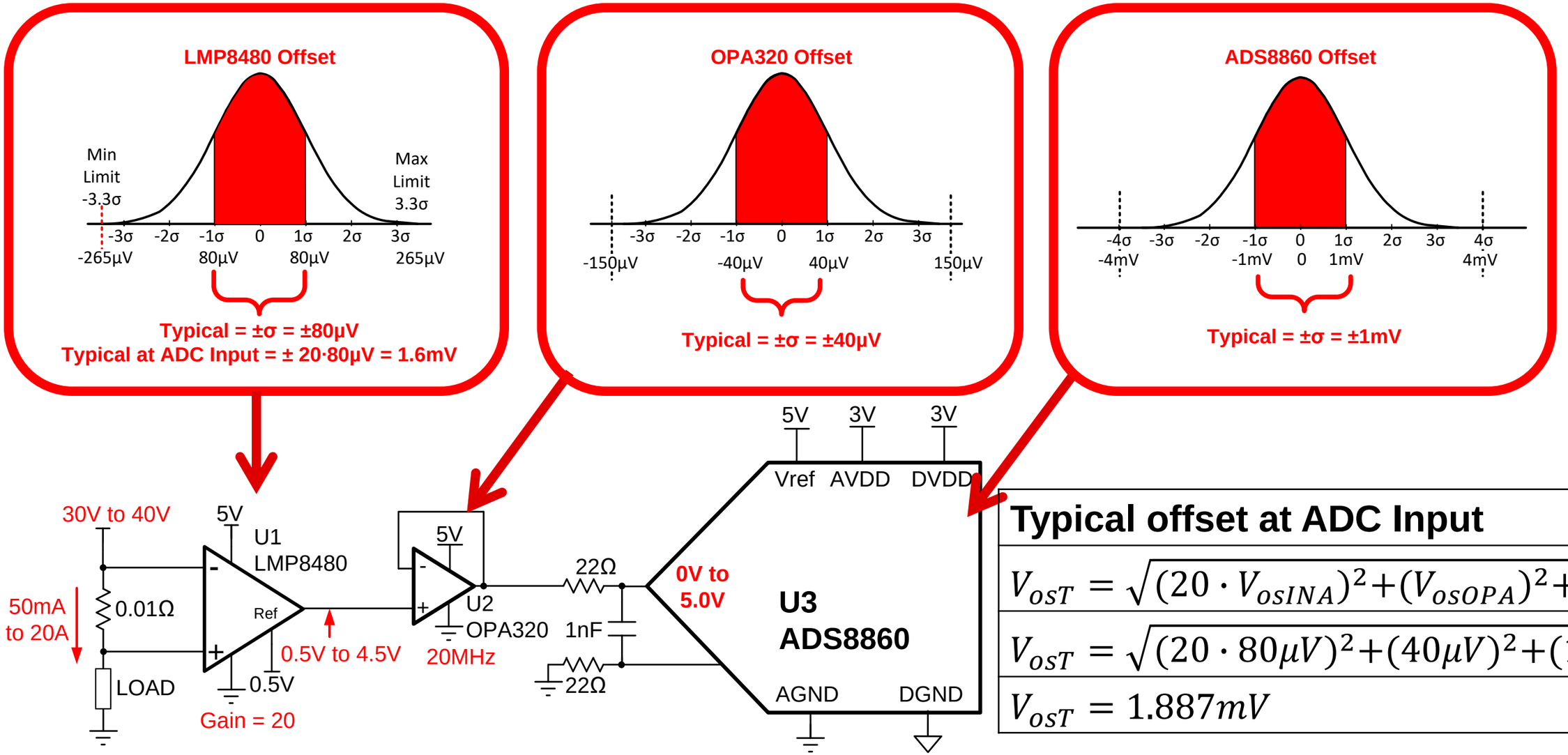
Compounding probabilities “near” worst case





The probability that all three offsets are near worst case
$P = P(A) \cdot P(B) \cdot P(C)$
$P = (0.02227)(0.02266)(0.02272)$
$\%P = 100 \cdot P = 0.0011\%$

A more practical approach: use the typical limit

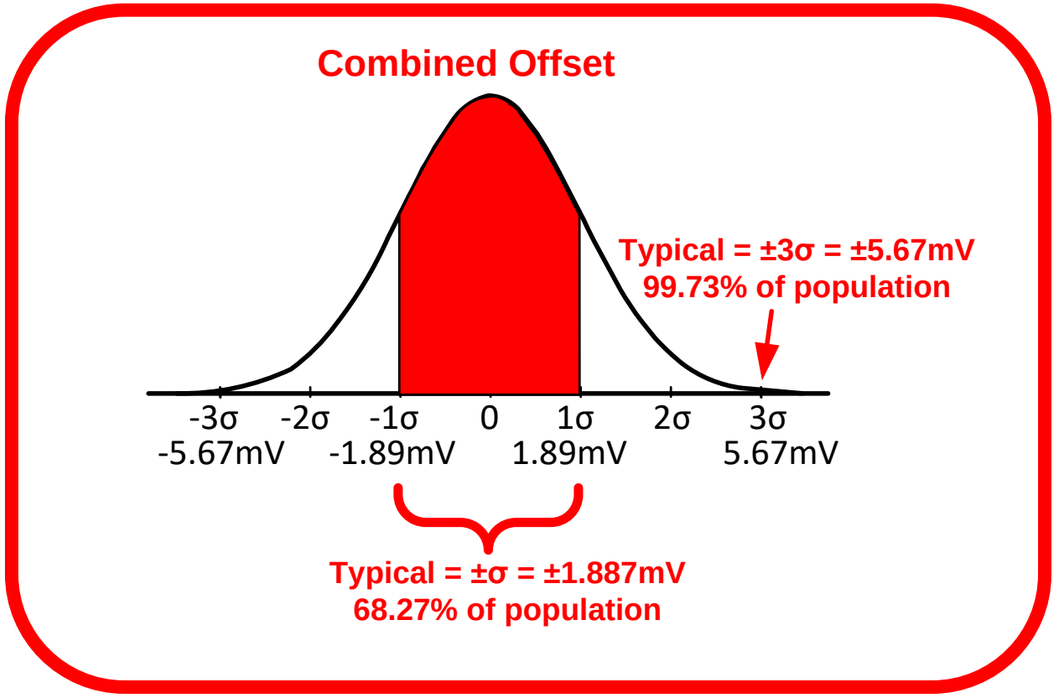


Typical offset at ADC Input
$V_{osT} = \sqrt{(20 \cdot V_{osINA})^2 + (V_{osOPA})^2 + (V_{osADS})^2}$
$V_{osT} = \sqrt{(20 \cdot 80\mu V)^2 + (40\mu V)^2 + (1mV)^2}$
$V_{osT} = 1.887mV$

A more practical approach: use typical

Number of Standard deviations	Probability Inside limit	Probability Outside limit
±1·σ	68.27%	31.73%
±2·σ	95.45%	4.55%
±3·σ	99.73%	0.27%
±4·σ	99.9937%	0.0063%
±5·σ	99.99994%	$5.73 \cdot 10^{-5}$ %
±6·σ	≈100%	$1.97 \cdot 10^{-7}$ %

Set end system specifications based on risk tolerance



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Thanks for your time!
Please try the quiz.

Quiz: Statistics Behind Error Analysis

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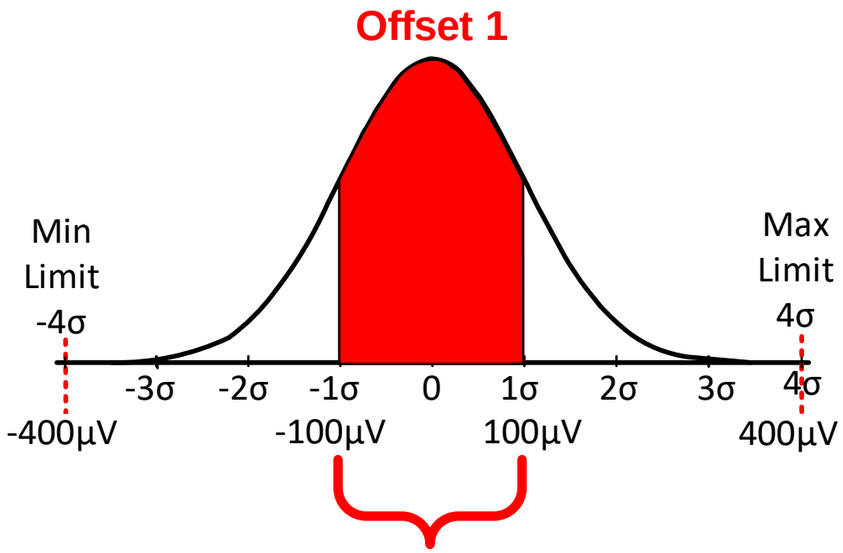
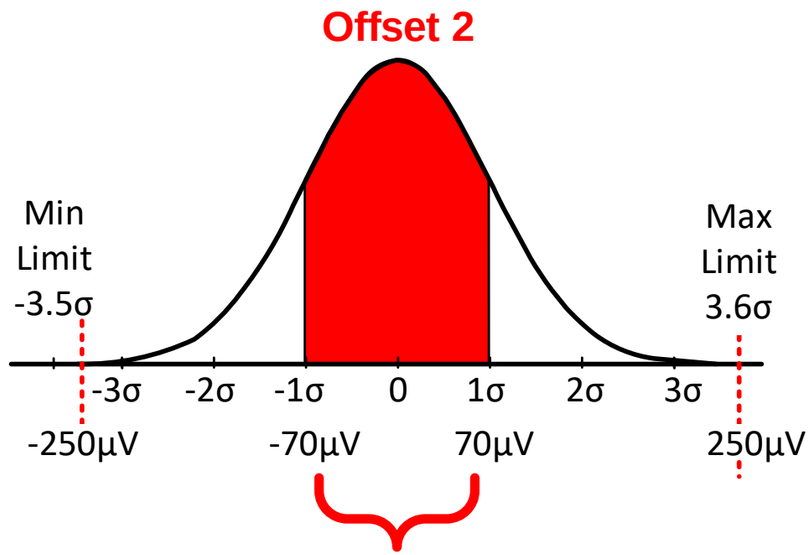
Quiz: Statistics Behind Error Analysis

1. The two uncorrelated Gaussian distributions below are being added. Draw the graph for the sum of the two distributions.



Typical = ±σ = ±100µV



Typical = ±σ = ±70µV

Quiz: Statistics Behind Error Analysis

2. What is the statistical significance of the typical offset specification?
   a) The typical offset specification is the mean offset.
   b) The typical is the mean plus one standard deviation. However, typically the mean is near zero so typical can be approximated as one standard deviation.
   c) The typical is tested and any device that exceeds the typical value is discarded.
   d) 99.7% of devices will be inside the typical limit.

3. When combining error sources A and B, they should be added _____.
   a. Directly (Total Error = A + B).
   b. Using Simpson's rule
   c. Using the Adaptive Runge-Kutta Method
   d. As the square root sum of the squares ($Total\ Error = \sqrt{A^2 + B^2}$)

Solutions

Quiz: Statistics Behind Error Analysis

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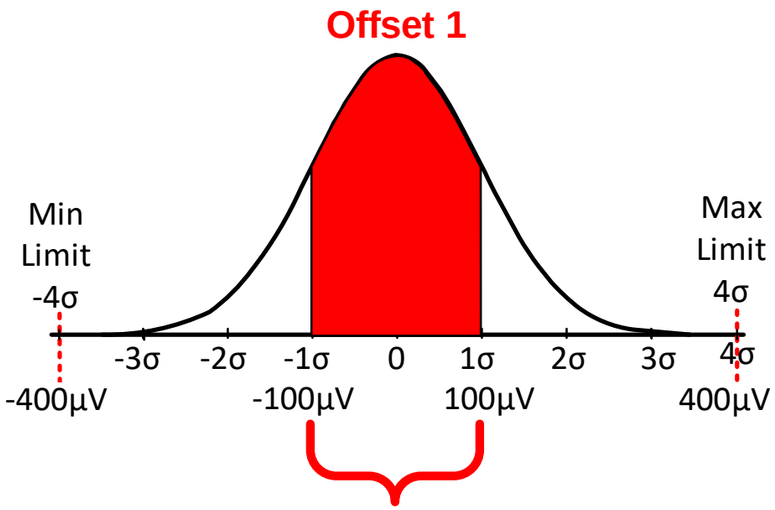

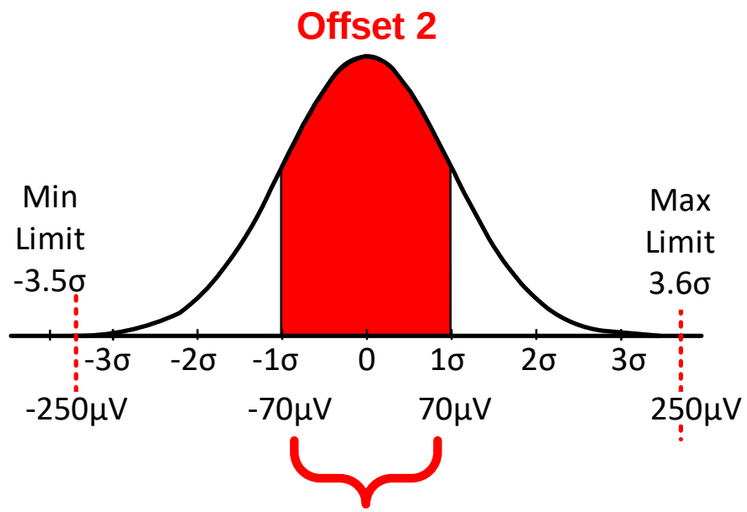

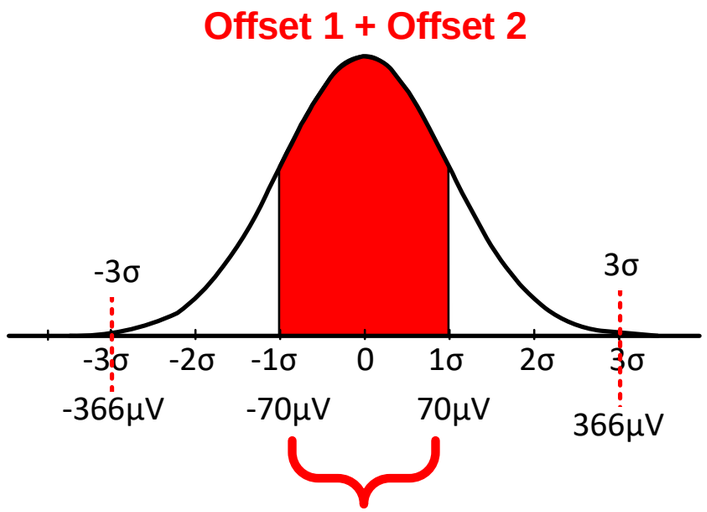

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