ADC Effective Number of Bits and Noise-Free Resolution

Quantisation noise, total noise with analogue input noise, signal-to-noise ratio for a full-scale sine, effective number of bits and noise-free bits of an ADC.

Method: Quantisation noise and SNR–ENOB relation

Input parameters

Unit system: SI

Parameter	Value	Unit
ADC resolution (bits)	16.000	
Full-scale range (peak-to-peak)	5.0000	V
Analogue noise referred to input (rms)	60.000	µV

Calculated results

Parameter	Value	Unit
LSB size	76.294	µV
Quantisation noise (rms)	22.024	µV
Total noise (rms)	63.915	µV
SNR for a full-scale sine (dB)	88.837	
Effective number of bits	14.465	
Noise-free bits	13.533	

Notes for this case

• Quantisation noise q/√12 adds in RSS with analogue noise; for a full-scale sine (rms V_FS/2√2), ENOB = (SNR − 1.76)/6.02. Noise-free bits use the peak-to-peak noise (about 6.6 σ) and tell how many bits stay steady in a static reading. Averaging N samples gains about ½·log₂N bits when the noise is random.

Formula and method

$$q = \frac{V_{FS}}{2^N}, \quad v_{tot} = \sqrt{\frac{q^2}{12} + v_n^2}, \quad ENOB = \frac{SNR - 1.76}{6.02}$$

Variables

N	ADC resolution (bits)	-
V_{FS}	Full-scale range (peak-to-peak)	V
v_n	Analogue noise referred to input (rms)	V
q	LSB size	V
$q/\sqrt{12}$	Quantisation noise (rms)	V
v_{tot}	Total noise (rms)	V
SNR	SNR for a full-scale sine (dB)	-
$ENOB$	Effective number of bits	-
NFB	Noise-free bits	-

Method and standards

ADC noise.

Assumptions and limits

- White noise; full-scale sine reference.

References

Quantisation noise and SNR–ENOB relation

Report details

Report reference	FCC-P7A7-FCR8 (the same inputs always give the same reference)
Generated	23 November 2026, 18:38 UTC
Calculator	ADC Effective Number of Bits and Noise-Free Resolution
Method last reviewed	17 November 2026
Software release	FireCAD Calc, release of 22 November 2026
Release checks	3 reference cases of this calculator, computed independently, are checked on every release

Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

This calculator online

https://calc.firecad.com/instrumentation/signals-calibration/adc-enob-noise

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.