

ENOB Quick Reference Guide

Effective Number Of Bits Calculator (ENOB) is a program for the HP50g calculator that aids in the design and analysis of data converter (ADC and DAC) application circuits. ENOB calculates the effective number of bits of an ideal data convertor. Each parameter can be entered or found.

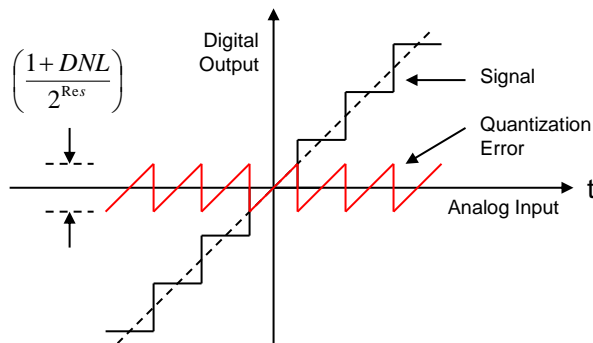
Parameters

1. Effective Number Of Bits, **ENOB**, in bits
2. Signal to Noise and Distortion, **SINAD**, in dB
3. Resolution, **Res**, in bits
4. Bandwidth, **BW**, in % of the Nyquist frequency, or, Over Sample Ratio, **OSR**, as a multiple of the sample frequency
5. Average Differential Nonlinearity, **DNL**, in LSB
6. Clock Jitter, **Tj**, in PPM rms of the clock period
7. Analog Referred Noise, **Vn**, in LSB rms
8. Total Harmonic Distortion, **THD**, in % or dB.

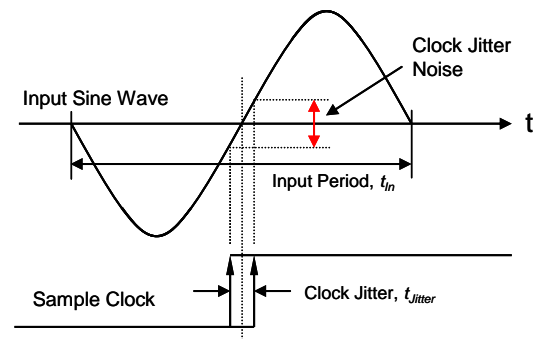
Equations

$$ENOB = \frac{SINAD - 10 \cdot \log\left(\frac{3}{2}\right)}{20 \cdot \log(2)}$$

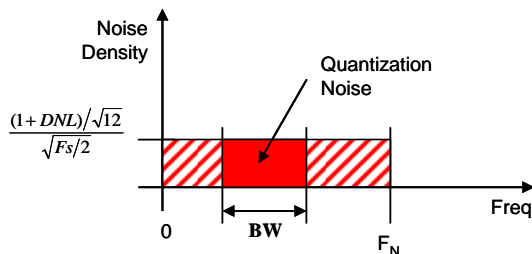
$$SINAD = -20 \log \sqrt{\underbrace{\frac{2}{3} \left(\frac{\sqrt{\frac{BW}{100}} (1 + DNL)}{2^{Res}} \right)^2}_{\text{Quantization Noise}} + \underbrace{\left(2\pi \frac{Tj}{10^6} \right)^2}_{\text{Clock Jitter Noise}} + \underbrace{\left(\frac{2 \cdot \sqrt{2} \cdot Vn}{2^{Res}} \right)^2}_{\text{Analog Noise}} + \underbrace{\left(\frac{THD_{\%}}{100} \right)^2}_{\text{THD}}}$$



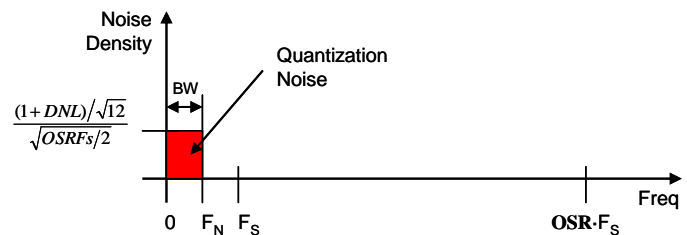
Quantization Noise (Res and DNL)



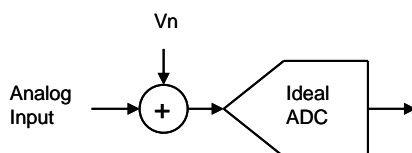
Clock Jitter Noise (Tj)



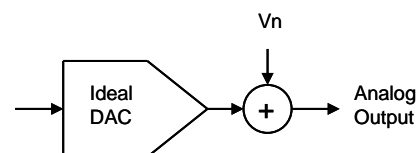
Quantization Noise (BW)



Quantization Noise (OSR)

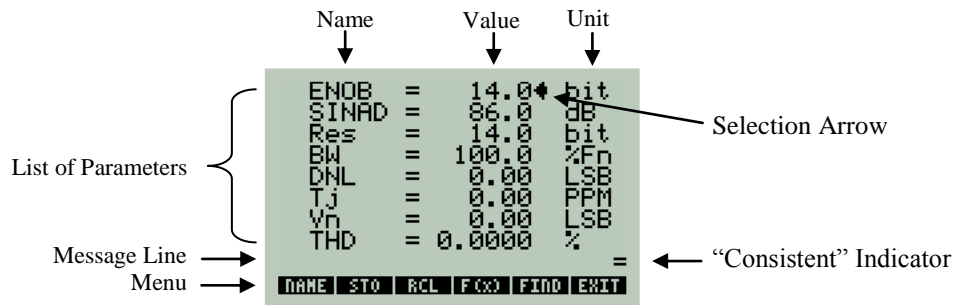


ADC Input Referred Noise (Vn)



DAC Output Referred Noise (Vn)

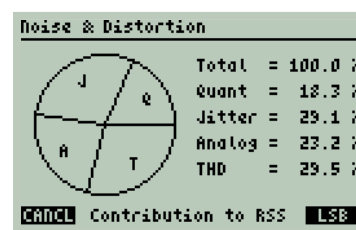
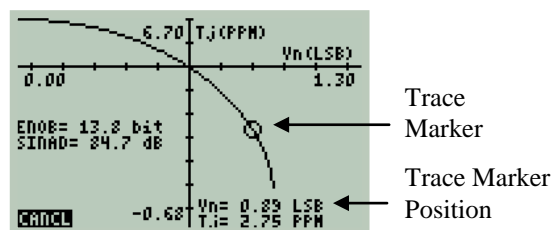
Parameter Display and Commands



- ▼ or ▲ select a parameter, as indicated by the selection arrow
- ▶ display an alternative parameter (indicated by a small dot right of the selection arrow)
- ◀ (insert) insert a parameter value. Press **ENTER** when finished.
- ◀ (delete) delete a parameter value. Press **ENTER** when finished.
- F1** () display a description of the selected parameter in the message line
- ◀ **F1** () display the full precision of the selected parameter in the message line
- F2** () store all parameters
- F3** () recall all stored parameters
- F4** () plot any parameter with respect to any other parameter. First selects the x parameter, then y.
- ◀ **F4** () display a pie chart of all noise and distortion sources
- F5** () find the selected parameter
- F6** () or **ON** (Cancel) exit the program
- ◀ **F6** () launch previous run calculator (for physical calculators only - requires CALC)
- ▶ **ON** turn off the calculator
- NXT** **F1** () display the equations used by ENOB
- NXT** **F2** () export the selected parameter to the stack upon exiting
- NXT** **F3** () import a number present in level 1 of the stack when ENOB was launched, to the selected parameter. The import value is automatically displayed on the message line.
- NXT** **F4** () enter all default parameter values. Parameters are not stored until is executed.

The equal sign (=) indicates all the parameters are consistent with each other and will appear following a **F5** () command. The not equal sign (≠) appears following an entry, indicating that the parameters may not be consistent.

Plot Displays and Commands ()



- ▲ Zoom out
- ▼ Zoom in
- ▶ ◀ Move trace marker left by 1 pixel
- ▶ ◀ Move trace marker left by 1/2 division
- ▶ ◀ Move trace marker left by 2 divisions
- ▶ ◀ Move trace marker right by 1 pixel
- ▶ ◀ Move trace marker right by 1/2 division
- ▶ ◀ Move trace marker right by 2 divisions
- F1** () Return to the parameter display
- F6** () display the noise in LSB RMS
- F6** () display the noise as % of RSS total
- F1** () Return to the parameter display