

Signal-to-noise ratio and dynamic range definitions

The Signal-to-Noise Ratio (SNR) and Dynamic Range (DR) are two common parameters used to specify the electrical performance of a spectrometer. This technical note will describe how they are defined and how to measure and calculate them.

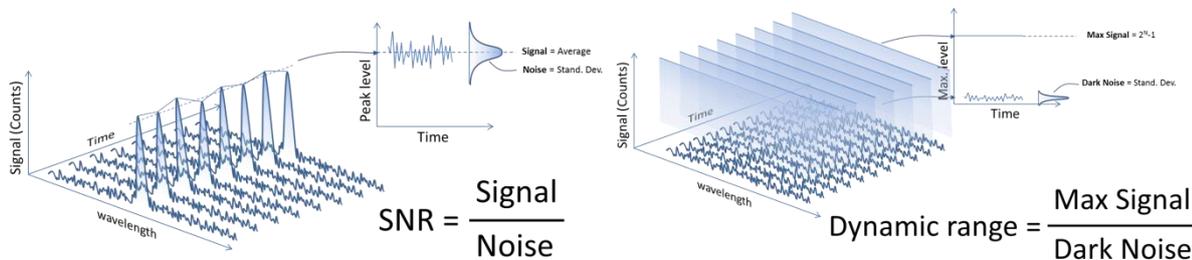


Figure 1: Definitions of SNR and SR.

The signal out of the spectrometer is a digital signal between 0 and 2^N-1 , where N is the number of bits in the Analogue-to-Digital (A/D) converter on the electronics. Typical numbers for N range from 10 to 16 leading to maximum signal level between 1,023 and 65,535 counts.

The Noise is the stochastic variation of the signal around a mean value. In Figure 1 we have shown a spectrum with a single peak in wavelength and time. As indicated on the figure the peak signal level will fluctuate a small amount around the mean value due to the noise of the electronics. Noise is measured by the Root-Mean-Squared (RMS) value of the fluctuations over time.

The SNR is defined as the average over time of the peak signal divided by the RMS noise of the peak signal over the same time. In order to get an accurate result for the SNR it is generally required to measure over 25 -50 time samples of the spectrum.

It is very important that your input to the spectrometer is constant during SNR measurements. Otherwise, you will be measuring other things like drift of you lamp power or time dependent signal levels from your sample.

If you store your 25 – 50 measured spectra using Excel, you can use the two functions AVERAGE and STDEV to calculate the SNR. For each wavelength (or pixel) in your spectrum you calculate the mean with the AVERAGE function and the RMS value by the STDEV function as demonstrated in Figure 2.

The Dynamic Range is defined as the maximum possible signal level divided by the noise level, when there is no light entering the spectrometer. The latter is called the dark noise of the spectrometer for obvious reasons.

The dark noise is measured by taking 25 – 50 dark level measurements and calculating the RMS level with the STDEV for each wavelength (or pixel). The Dynamic Range is then calculated as 2^N-1 divided by the dark noise.

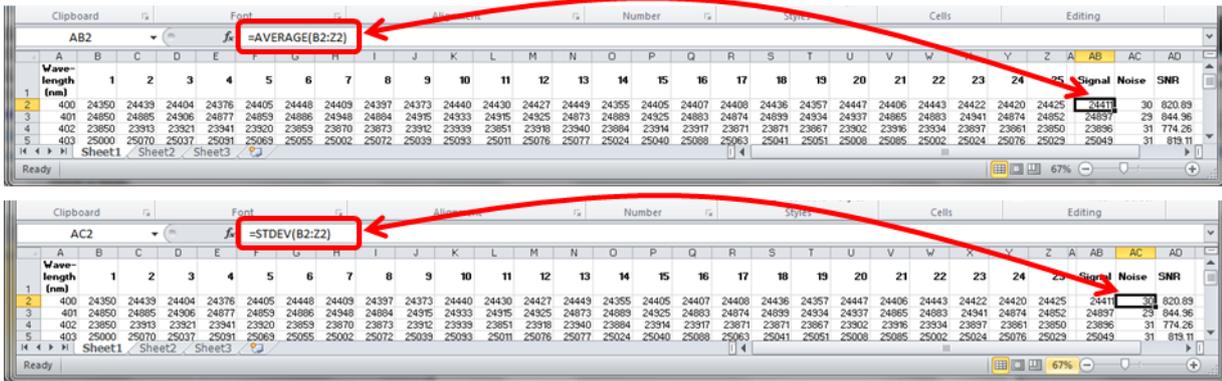


Figure 2: Example of calculation of Signal and Noise for 25 measurements in Excel.