
Engineering Note

Topic: Spectrometer Signal-to-Noise and Dynamic Range Comparison

Products Affected: Spectrometers

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Overview

For all Ocean Optics Spectrometers, we specify the Signal-to-Noise (S/N) and the Dynamic Range. These parameters are often used interchangeably. However, it's important to realize the performance parameters that comprise each measurement.

Dynamic Range

The dynamic range of a system is defined as the full scale signal divided by the minimum resolvable signal. For Ocean Optics spectrometers, we define the minimum resolvable signal as the standard deviation of the dark signal. Contributions to the dark signal include readout noise and other system electronics noise. Table 1 shows the dynamic range and the parameters that comprise the measurement for each of the spectrometers.

A common misunderstanding is to interchange dynamic range and the A/D converter's resolution. However, a dynamic range measurement includes the system's minimum noise level (e.g., detector readout noise, electronic noise, quality of the design, etc.). It's most applicable to low light level applications like fluorescence because it defines the minimum detectable signal

It's important to realize that the dynamic range is a measurement of the spectrometer's performance that does not include light (i.e., not the way it is used). Thus, Signal-to-Noise (S/N) measurement is typically a more meaningful measurement.

Signal-to-Noise

The S/N measures how precisely the spectrometer can measure a certain light level. The S/N is computed by determining the standard deviation for a given light level divided by the standard deviation of the measurement. While the S/N varies with the light level, Ocean Optics (and most other manufacturers) specify it at its maximum level, which is the full scale illumination. The S/N is shown in Table 1 for the various spectrometers.

This data shows that the standard deviation of an illuminated detector is different than a dark detector. This is due to the probabilistic nature which governs light measurements. Ideally the spectrometer should only be limited by the optical shot noise, which indicates that the S/N increases as the square root of the number of photons collected.

This table does not specify the relative sensitivity or other key performance factors. Typically the selection of a spectrometer includes many factors; it's important to not select a unit based on these parameters alone.

Table 1: Ocean Optics Spectrometer Comparison: Dynamic Range and S/N

	USB2000 HR2000	S1024 DW	S1024 DWX *	NIR	HR4000	USB4000	HR2000+	QE65000
Full Scale Signal (counts)	4096	4096	4096	65536	16,384	65,536	16,384	65535
Dark signal RMS (counts)	3.4	1.5	1	12	12	50	12	2.5
Dynamic Range	1200	2700	4000	5000	1300	1300	1300	25000
Full Scale RMS Signal (counts)	15	2	1	16	55	220	60	55
S/N Ratio	275	2000	4000	4000	300	300	275	1200
Notes: All values are typical and do not include signal averaging or computation								
* = When coupled with an ADC1000-USB, which is a 12 bit A/D system								