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The flat-top of a spectral peak

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When recording a narrow spectral peak with an Optical Spectrum Analyzer (OSA), it can happen that you observe a flat-top on the peak. It is important to understand that this has nothing to do with saturation of the detector circuit, but is explained by the recording method used in the OSA. Knowing how to interpret the flat-top is crucial and can be used to your advantage.

The flat-top profile is only produced in situations where the resolution setting is lower than the width of the spectral peak. For example, in figure 1, the spectral width of a Helium Neon laser (1523nm line) is much narrower than the chosen 20nm resolution.

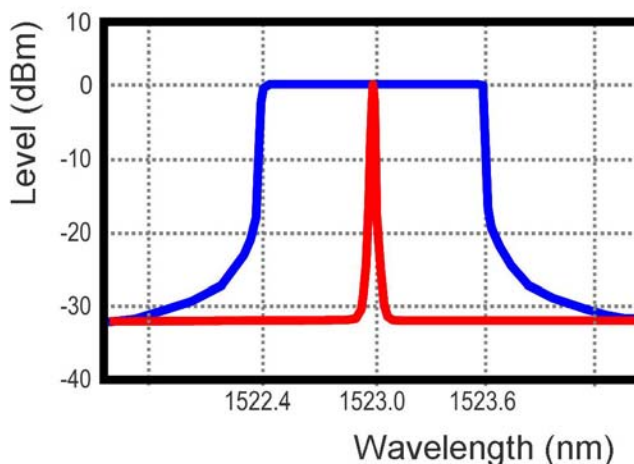


Figure 1 – The spectrum of the 1523 nm Helium-Neon laser line, recorded with a 20nm resolution (yellow trace) and with a 2nm resolution (green trace).

To explain where the flat-top comes from, we need to look at the Czerny-Turner monochromator design (Fig. 2), in which the input wavelengths are separated spatially (different angles) using a diffraction grating. Rotation of the grating will shift the spectrum of wavelengths across an exit slit, blocking all light except for a narrow portion. The power of the light that passes through the slit is recorded as a function of the grating angle (i.e. as a function of the wavelength).

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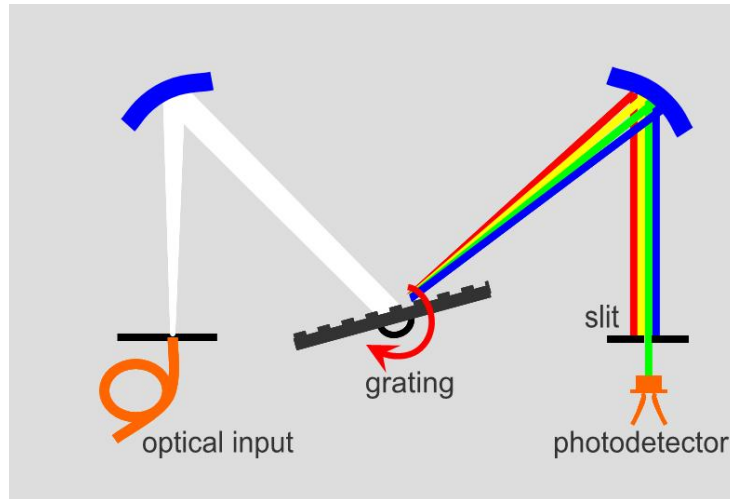


Figure 2 – The principle of the Czerny-Turner monochromator

The slit acts as a bandpass filter, and the width of the slit is an important factor that determines the spectral resolution of the monochromator (wide slit = low spectral resolution and vice versa).

When a low resolution setting (wide slit) is used to record a narrow spectral peak, 100% of the light beam will fit through the slit for a certain wavelength range (Fig. 3). The recorded OSA trace will show a broad peak with a flat-top. Because 100% of the light fits through the the slit, the level of the flat-top tells the total power inside the spectral peak.

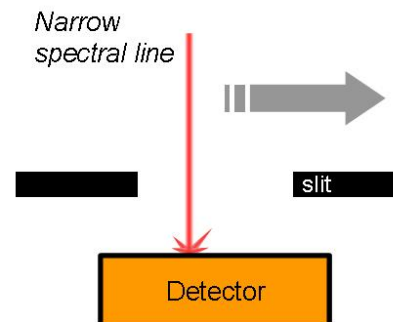
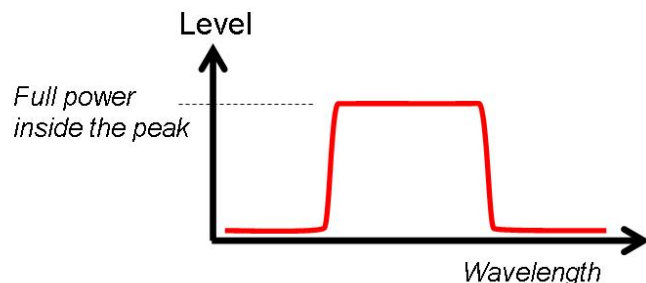


Figure 3 - As a narrow peak is swept across a wide exit slit, the photodetector measures full power of the spectral peak over a range of wavelengths, hence, producing a trace with a flat-top.



Accurate power measurement

A flat-top is essentially a confirmation that the complete spectral peak is captured by the slit, and you are not missing power stored in the flanks of the peak. A single measurement is sufficient to measure power, keeping the measurement error to a minimum.

This is important for (example) in Signal-to-Noise Ratio measurement in optical data communication. Here, modulation of an optical signal will shift part of the power into so called “modulation sidebands”. To measure the complete (broadband) signal power, the resolution must be low enough to capture the complete signal spectrum (carrier wave plus modulation sidebands). Then, a flat-top profile is a clear indication that the complete signal is captured, hence, providing an accurate value for calculation of the signal-to-noise ratio.

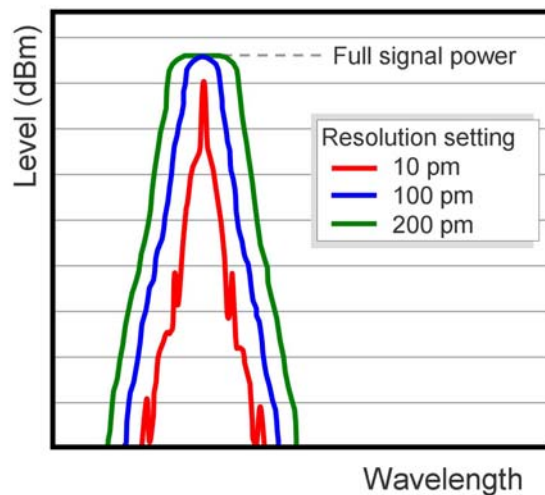


Figure 5 – 10Gb/s signal (NRZ modulation format). The complete signal power is captured with a resolution setting of lower than 100 pm.

Simple Instrument Check

An OSA is an opto-mechanical instrument, meaning that measurement accuracy depends on the mechanical stability of the instrument. Specially after rough transportation or after large temperature fluctuations, a quick evaluation of a flat-top and the symmetry of the profile can prove the condition of the OSA. For this check, a narrow laser peak needs to be recorded both in highest resolution setting and in lowest resolution setting. When the OSA is in a good condition, the flat-top of the low-resolution trace should be perfectly horizontal. Secondly, the low-resolution trace should be perfectly symmetrical around the (narrow) high resolution trace.

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