Thermal Stability

Change of performance depending on the temperature can be of great importance in certain applications where accurate, repeatable results are vital.
All AvaSpec spectrometers have no moving parts inside and are in nature extremely robust and stable.
The ULS (Ultra Low Straylight) benchdesign provides exceptional thermal stability.
The thermal stability of our spectrometers is part of our comprehensive Quality Control procedure and therefore closely monitored during the production and assembly process. All of our spectrometers undergo overnight thermal cycling, during which wavelength shift, intensity drop and spectral tilt are registered and checked against our QC acceptance norm. More specifically,
the following test are being carried out during the thermal cycling from 15°C to 25°C to 35°C back to 25°C:

Full Width Half Maximum

During the thermal cycling the average FWHM value is measured and has to fit with a certain standard deviation within the QC acceptance norm.

Peakshift

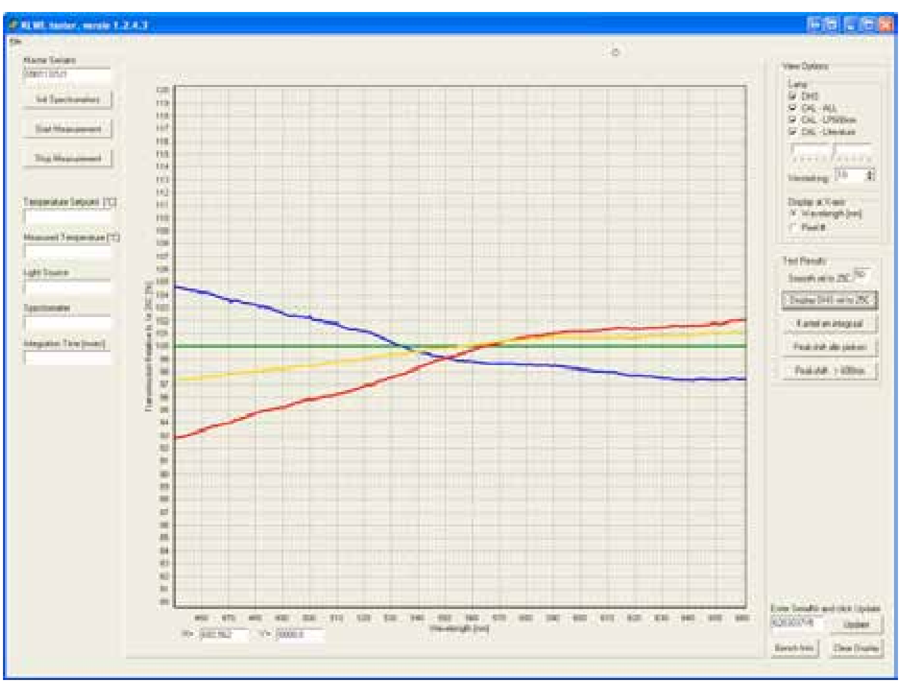
During thermal cycling the shift of peaks is monitored and depicted as shift in pixels per °C. Depending on the grating angle the maximum allowed peakshift is defined, for most gratings the below values are the QC acceptance norm. For gratings with many lines/mm starting at high wavelengths (VD, VE), the peak shift can double.

The max allowed peakshift =± 0.1 pixel per °C for an AvaSpec-ULS2048 with a pixel pitch of 14µm. Average peakshift is ± 0.04 pixel per °C for an AvaSpec-ULS2048.
For an AvaSpec-ULS3648 with a pixel pitch of 8µm the max allowed peakshift is ± 0.17 pixel per °C. For the AvaSpec-NIR256 with relative large pixels of 50µm the peakshift is limited to ± 0.03 pixel per °C. For back-thinned and NIR detectors with a 25µm pitch as in the AvaSpec-HS1024x58/122 and AvaSpec-NIR512 the peakshift is limited to ± 0.06 pixel per °C.

Intensity stability and Spectral tilt

Temperature sensitivity on the intensity axis can have a number of reasons. First, the CCD detector itself has a temperature dependency, for most detectors there are black pixels that are read out and are subtracted from the rest of the data pixels, the so-called Correct for Dynamic dark (CDD). However, CDD will not correct for spectral tilt, which is partially also a detector property. The aluminum optical bench and the optical components are engineered in such a way that the thermal expansion does not lead to large increase in tilt or sensitivity.
For most spectrometers the average intensity increase/decrease is within ±4% for ± 10°C thermal cycling.
Minimal tilt-parameters can be achieved with back-thinned detectors.

In the figure below a typical test result for a thermal cycling can be seen.



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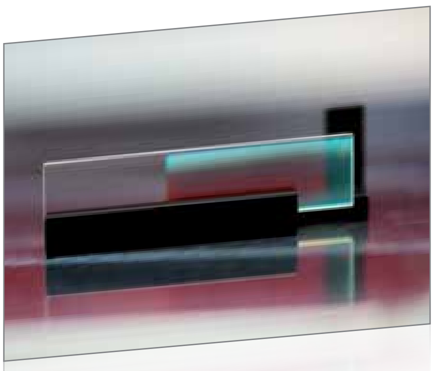
Spectrometers

Stray-Light and second order effects

Stray-light is radiation of undesired wavelengths that activates a signal at a detector element. Sources of stray-light can be:

- *Ambient light*
- *Scattering light from imperfect optical components, or reflections of non-optical components*
- *Order overlap*

Order-Sorting Window in holder



Avantes symmetrical Czerny-Turner optical bench designs favor stray-light rejection relative to crossed designs. Additionally, Avantes Ultra-Low Stray-light (AvaSpec-ULS) spectrometers have a number of internal measures to reduce stray-light from zero order and backscattering.

When working at the detection limit of the spectrometer system, the stray-light level from the optical bench, grating and focusing mirrors will determine the ultimate limit of detection. Most gratings used are holographic gratings, known for their low level of stray-light. Stray-light measurements are conducted using a halogen light source and long-pass or band-pass filters.

Typical stray-light performance for the AvaSpec-ULS and a B-type grating is <0.06% at 250-500 nm. Second order effects, which can play an important role for gratings with low groove frequency, and therefore a wide wavelength range, are usually caused by the 2nd order diffracted beam of the grating. The effects of these higher orders sometimes need to be addressed using filtering. The strategy is to limit the light to the region of the spectra, where order overlap is not possible.

Second order effects can be filtered out, using a permanently installed long-pass optical filter in the SMA entrance connector or an order-sorting coating on a window in front of the detector. The order-sorting coatings on the window typically have one long-pass filter (600 nm) or 2 long-pass filters (350 nm and 600 nm), depending on the type and range of the selected grating.

In Table 6, a wide range of optical filters for installation in the optical bench can be found. The filter types that are 3 mm thick give a much better 2nd order reduction than the 1 mm filters. The use of following long-pass filters is recommended: OSF-475 for grating NB and NC, OSF-515 / 550 for grating NB and OSF-600 for grating IB. For backthinned detectors, such as the 2048XL and 1024x58/122 we recommend an OSF-305 Filter, when the starting wavelength is 300 nm and higher.

In addition to the order-sorting coatings, we apply partial DUV coatings on the part of the Sony 2048 detectors which detects the UV light. Coating only this part of the detector and not the part for VIS/NIR detection avoids second-order effects from UV response and enhances sensitivity and decreases noise in the visible range

This partial DUV coating is done automatically for the following grating types:

- UA for 200-1100 nm, DUV400, only first 400 pixels coated
- UB for 200-700 nm, DUV800, only first 800 pixels coated

Table 6 Filters installed in AvaSpec spectrometer series

OSF-305	Permanently installed order-sorting filter @ 305 nm
OSF-395	Permanently installed order-sorting filter @ 395 nm
OSF-475	Permanently installed order-sorting filter @ 475 nm
OSF-515	Permanently installed order-sorting filter @ 515 nm
OSF-550	Permanently installed order-sorting filter @ 550 nm
OSF-600	Permanently installed order-sorting filter @ 600 nm
OSF-850	Permanently installed order-sorting filter @ 850 nm
OSC	Order-sorting coating with 600 nm long-pass filter for VA, BB (>350 nm) and VB gratings in AvaSpec-ULS2048(L)/3648/2048XL
OSC-UA	Order-sorting coating with 350 and 600 nm long-pass filter for UA gratings in AvaSpec-ULS2048(L)/3648/2048XL
OSC-UB	Order-sorting coating with 350 and 600 nm long-pass filter for UB or BB (<350 nm) gratings in AvaSpec-ULS2048(L)/3648/2048XL
OSC-HS500	Order-sorting coating with 350 and 600 nm long-pass filter for HS500 gratings in AvaSpec-HS
OSC-HS900	Order-sorting coating with 600 nm long-pass filter for HS900 gratings in AvaSpec-HS
OSC-HS1000	Order-sorting coating with 350 nm long-pass filter for HS1000 gratings in AvaSpec-HS
OSC-NIR	Order-sorting coating with 1400 nm long-pass filter for NIR100-2.5 and NIR150-2.0 gratings in AvaSpec-NIR256/512-2.2/2.5TEC