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Engineering Note

Topic: Flame-T, HR4000 and USB4000 Shutter Mode Performance in Hardware Trigger Mode

Products Affected: Flame-T, HR4000 and USB4000 Spectrometers

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Description

The Flame-T, HR4000 and USB4000 Spectrometers utilize the Toshiba TCD1304 CCD Detector. When operating a Flame-T/HR4000/USB4000 Spectrometer with this detector in External Hardware Edge, External Synchronous, or External Hardware Level Trigger mode, you will find some subtle differences between spectra obtained in Normal versus one of the External Hardware Trigger modes. This is due to the differences in the timing signals between the two operating modes. Specifically when operating in an External Hardware Trigger mode, the Toshiba TCD1304 detector is being operated in Shutter mode. This is done to continuously clear the detector while waiting for the trigger signal. With this approach, all of the key performance specifications are maintained (e.g., Signal-to-Noise, RMS noise, Baseline Stability, etc).

As with all new features, there are tradeoffs and limitations that exist; the TCD1304 Shutter mode operation is no different; there are limitations that must be realized in it operation. These limitations are outline below.

Sensitivity

The sensitivity of the detector changes between Shutter mode and Nonshutter mode operation. Figure 1 shows the spectra from a broadband light source measured at the same integration time between Normal and External Hardware Trigger mode. Ocean Optics has verified that this change in spectra is being generated by the CCD itself and not some other electronic anomaly. Figure 2 shows the trigger mode effects when a light source with fine spectral features is used.

Due to this effect, it's necessary to acquire all spectra used in an experiment (i.e., dark or reference) in the same trigger mode as the sample. Ocean Optics has investigated numerical techniques to compensate for this change but has not developed a reliable technique. The implications of this are that data analysis techniques that switch between Shutter mode and Nonshutter mode operation cannot be used. Common applications that have limitations are the following:

- Time Normalized Analysis below 3.8ms
- Absolute Irradiance Measurements below 3.8ms
- Color Measurements below 3.8ms

If you need performance below 3.8ms, Ocean Optics offers the Flame-S, HR2000+ and USB2000+.

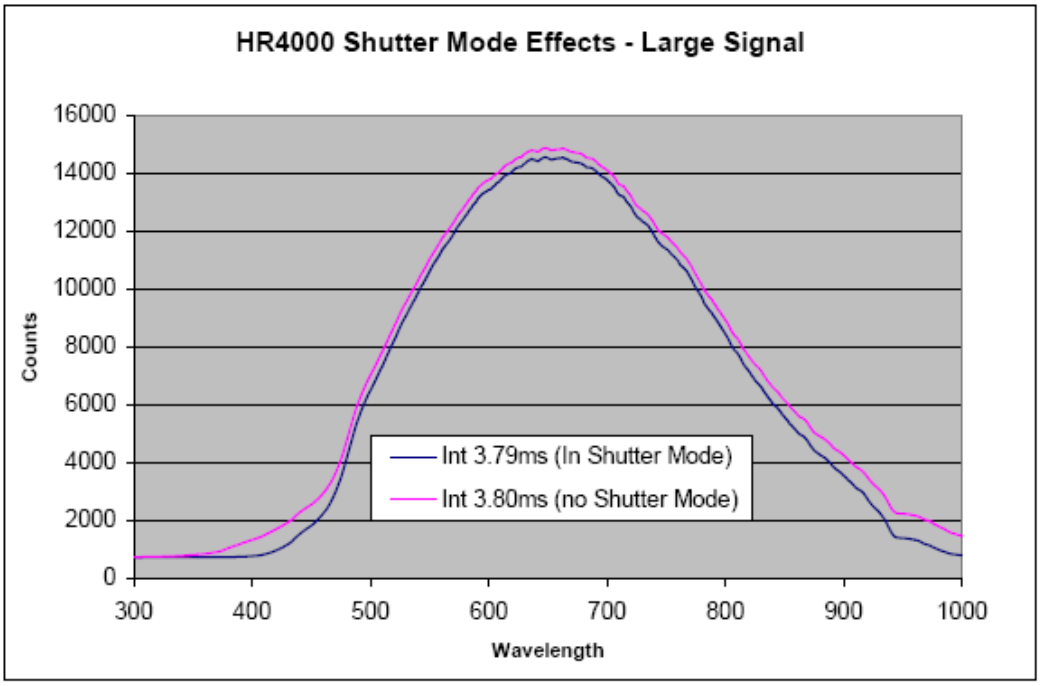

Figure 1. Large signal sensitivity comparison between normal and shutter mode operation.

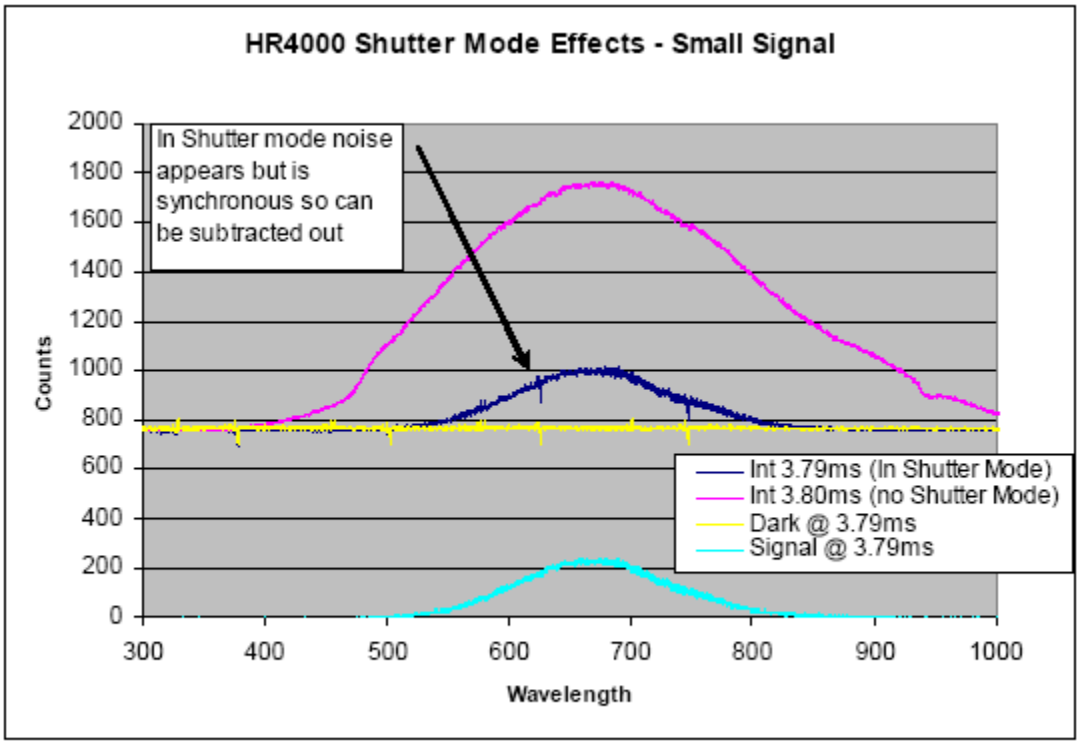

Figure 2. Synchronous "noise" which occurs in shutter mode can be subtracted out.

Dark Spectra

When operating the detector in Shutter mode, there is some additional synchronous "noise" that appears (see Figure 2). While this is commonly referred to as noise, its "crosstalk" that occurs in the detector between the shutter pin and analog output signal. While in Shutter mode, this crosstalk will change in duration across the spectra because the shutter pin is being driven for different lengths in time. Fortunately this crosstalk is synchronous and thus subtracts out to reveal the correct spectra (see Figure 2).

Linearity

The linearity of the detectors changes between Shutter mode and Nonshutter mode operation. Thus, applications which require linearity correction below 3.8ms operation should not be used.

Bleed-through

The TCD1304 shutter is not 100% effective so the sum of the photons that occur outside the shutter interval are collected and summed into the overall signal. For this reason, the HR4000/USB4000 spectrometers are not suitable for LIBS and other "gated" operations.