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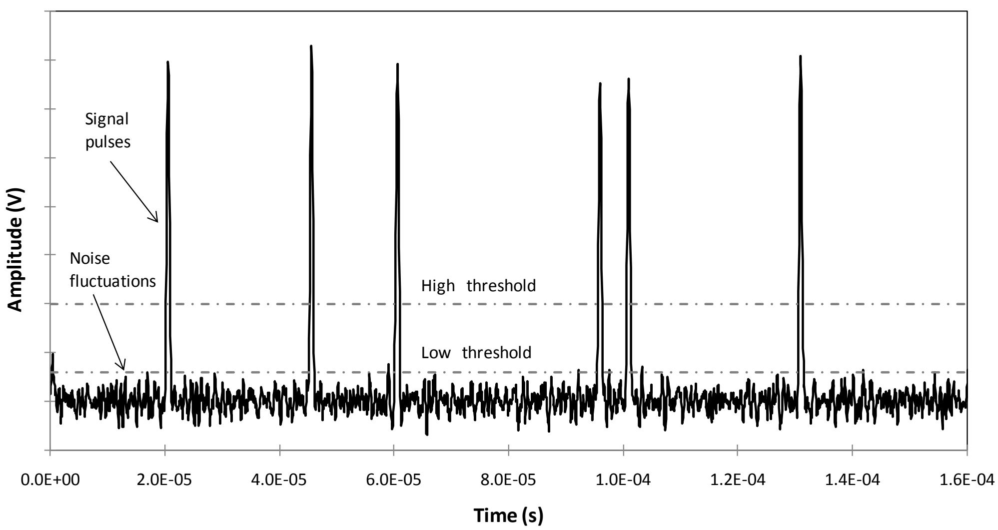
AMETEK MATERIALS ANALYSIS DIVISION

Understanding Thresholds in Amptek DPPs

What are the thresholds?

There are several thresholds used in Amptek's digital pulse processors. These are lower level thresholds, used to distinguish signal pulses from noise fluctuations. The plot below illustrates a typical output from the pulse shaper. A few signal pulses are seen, superimposed on a baseline of noise fluctuations. This is intrinsic noise, due to shot noise through the detector, thermal noise in the preamplifier, and other unavoidable noise sources. One can reduce the noise but cannot eliminate it. To the circuitry in the digital processor, the peak of a noise fluctuation is the same as the peak of a signal pulse except for amplitude. The thresholds tell the circuitry to ignore small pulses.

The plot shows two possible threshold settings. With the high threshold, far above noise, noise pulses will never be detected. However, small signal pulses will also be excluded. With the low threshold, small signal pulses will be detected, but some noise pulses will be recorded as signal pulses. The measured count rate will be larger than the signal count rate. The ideal threshold setting is just above the noise, where the count rate with no signal present is about 1 cps.



What is the fast threshold?

- The fast threshold is simply the low level threshold on the fast channel. The fast channel count rate is used to estimate the input count rate.
- If the fast threshold is too low, then an erroneously high input count rate will be reported. The fast channel is also used for pile-up rejection: if the fast channel detects two pulses which would overlap in time in the slow channel, and PUR is enabled, both are rejected. If the fast threshold is too low and so triggers on noise, every real signal pulse will be followed by a false noise pulse, rejecting everything.
- The fast channel is usually noisier than the slow channel (it has a higher noise bandwidth due to its faster peaking time). The fast threshold is usually higher than the slow threshold.

What is the slow threshold?

- The slow threshold has two functions. It is a low level threshold on the slow channel and it is also used in the peak detect logic: the shaped pulse must fall from its peak value by at least the slow threshold.
- If the slow threshold is too low, then a "tail" of noise pulses will be seen at the lowest channels. If it is extremely low, then one can see "extra" pulses near the photopeaks and in the background (a noise fluctuation on the rising or falling edge of the pulse may be recorded as a signal).
- If the slow threshold is too high, then one fails to detect the smallest signal pulses and the dead time between pulses is extended.

What is the LLD?

- It is best to set the fast and slow thresholds just above the noise in the respective channels. This will usually result in the fast threshold being higher than the slow threshold. This, in turn, means that small signal pulses are measured in the slow channel and not in the fast channel – this can give a slow channel count rate exceeding the fast channel count rate.
- The LLD is an independent threshold in the slow channel which does not affect the peak detect. One should set the slow threshold just above the noise, then can raise the LLD higher than the slow threshold until the fast and slow channels are recording the same number of pulses, to give the best count rate corrections.

Why do I need to adjust thresholds after changing other parameters?

Many parameters will change the rms noise seen at the output. The gain, the peaking time, the fast channel peaking time, the flat top, the bias voltage, the temperature, and many others will change the rms noise. The thresholds should be set above the noise, so if the noise is changed, then the thresholds should be changed.

There will usually be a nonzero offset: "zero amplitude" for pulse does not occur in MCA channel zero but is usually a few MCA channels positive. The offset scales with the rms noise, so a parameter change which affects rms noise will have a larger effect on threshold than might be expected. Also, since the rms noise is usually high in the fast channel, its offset is high, so the fast threshold can be larger than expected.

What does "autotune" do?

Autotune operates on both slow and fast thresholds. It initially sets the thresholds to zero, which causes a very high count rate on the fast and slow channels. It then raises these thresholds until the fast and slow count rates each reach 1 count per second.

What can I do if autotune fails?

Most often, when autotune fails, it does so because the signal is not zero. If you have an excitation source giving even 5 counts per second, the algorithm will keep raising the threshold because the rate will never drop to 1 cps. Once the threshold is raised to 25% of full scale, the algorithm concludes it failed.

If possible, remove the excitation source and repeat. Sometimes this is not possible: in the GammaRad, background radiation often yields tens of counts per second and this cannot be turned off. In this case, you can manually set the threshold to zero (or close) and will see a high count rate and a noise tail in the spectrum. Manually raise the values until the noise tail goes away, the counts approach a plateau (little change in rates with increasing threshold), and the fast and slow counts are equal.

What do the threshold numbers mean?

The slow threshold is in percent of full scale. At 1024 channels, a slow threshold of 1% is at channel 10.24. The signal processor measures the pulse heights to more precision than the reported number of channels, so the threshold can be at a fractional channel.

The fast threshold is in units of "channels", with a maximum of 512 channels. A setting of 5.1 is 1% of full scale. Note that the gain and offset are generally different in the fast and slow channels. The fast channel may exhibit ballistic deficit (its flat top may be as short as 12 ns) and the fine gain parameter does not apply to the fast channel, so the gain can be different. Because the rms noise is higher, the offset is higher. So the results cannot be easily compared between the two.

To visualize the fast threshold, Amptek's DPP permits one to view the fast channel spectrum (via advanced settings). Go to DPP Configuration, the MCA tab, and set MCA source to "FAST". This displays the histogram obtained in the fast channel. Set the DPP to delta mode, then adjust the slow threshold until the total count value in each second equals the input count value. The threshold seen on screen will equal the fast threshold.