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When do I need to use a preamp? (and other comments on signal levels and device saturation)

One of the very convenient things about Vigo MCT detectors is that many users will not require a preamplifier but can instead go directly into an oscilloscope for display of fast transients, usually laser pulses. When is this the case and when not? Briefly, the answer is, for a CW signal, you probably need a preamp, and for short pulses widely spaced in time, you probably do not need a preamp.

The question relates to saturation levels in the detector. We consider "saturation" to be the point at which the detector output deviates from linear by 20%. You might want to choose another percentage deviation from linearity, but the idea remains the same and in fact, once saturation begins it seems to happen quickly so there will not be a large difference whether we speak of 1%, 20% or 50% deviation.

Saturation is most easily described NOT in terms of input optical signal but in terms of output electrical signal. For example, for the model PD-10.6-3, we expect output saturation at about 10 millivolts for a CW signal, and at about 600 millivolts for a single short pulse. These represent the extreme cases. Since few if any users have oscilloscopes that will display a signal of 10 millivolts with much deflection on the CRT, those users trying to see a CW signal will pretty much always need a preamp. However, users whose input signals are short and strong (say < 1 μsec and > 5 watts peak) should be able to dispense with the amplifier and go direct to the scope using the PD-10.6-3. A certain amount of experimentation around these levels to optimize them should be expected.

Many users in fact have input waveforms that can be considered neither CW nor "short single shot" pulses. This gets us into the intermediate "quasi-CW" regime. There are no firm rules here, but some guidance is available from experience:

- Many CO_2 lasers are called "pulsed" but are in fact better described as modulated. Duty cycle is in the range of 50% and the modulation frequency is in the kHz region. These should be considered CW sources and a preamp used.
- Pulsed lasers with short pulses and duty cycles <<1% (for example pulses less than 1 μsec duration repeated at 1000 Hz) will probably act like single shot sources and the preamp can usually be omitted.
- Intermediate values of pulse length and duty cycle may act in an intermediate fashion.

How can you determine whether you are in the intermediate regime? Clue number one, if you cannot get more than a few millivolts out, despite raising the input power level, you are likely saturated and you had better reduce that input power ASAP before you fry the detector. A good way of seeing whether you are in saturation is to attenuate the input optical signal and see if the output electrical signal reduces proportionally. This is valid whether there is a preamp in the system or not. You do not need a calibrated optical filter to try this. For example, one piece of uncoated germanium 1 mm thick will transmit about 50% from 2 to 20 μm or so. So two pieces (not too close together to avoid interference effects) will transmit about 25%. Try one, then two, and if you do not see the expected T and T^2 reductions, back that input power off. No Ge on hand? Try a piece of window screen. Or take your input as the reflection from a scattering surface and increase the distance to reduce the signal. A diffuse reflector will attenuate as $1/r^2$ where r is the distance. A sometimes confusing symptom of saturation is appearance of a slower than expected fall time despite apparently credible rise of a pulse measurement. This can be due to thermal effects, and again the cure is to lower the power on the detector and if necessary, use a preamp.

These comments are directed specifically at the PD-10.6-series of detectors although they apply generally to all our devices. However, saturation is not so well know for most of the others, especially the immersed devices. Immersion is a tool to improve signal to noise and saturation concerns imply that you have excess signal and hence plenty of S/N. Therefore, the question is usually moot.

For sample numerical calculations on saturation levels, see the end papers to our publication "Predicting the Performance of a Photodetector"