Low Frequency Power Mode

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Abstract

This document describes the inherent problems involved with measuring average power for low frequency pulsed laser sources, and describes the new “Low Freq. Power Mode” being offered on many Ophir devices and meters to solve these problems. It describes how to use the new mode and mentions some tips for obtaining best results.

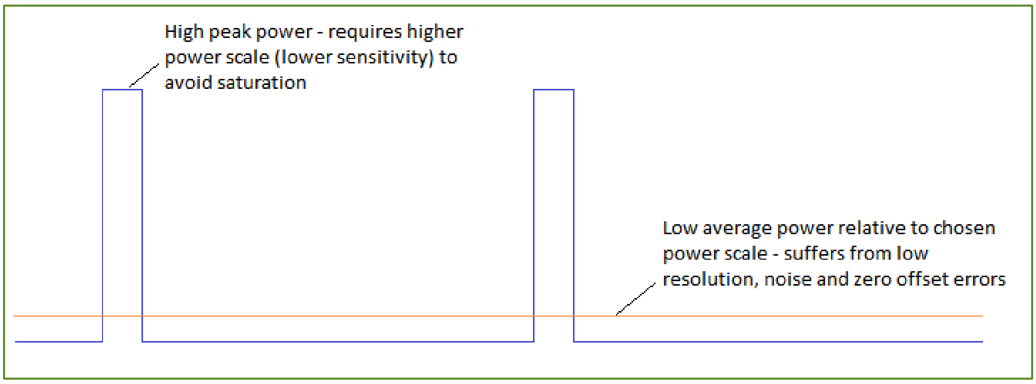
Introduction:

VCSEL sources have become very popular in the last few years and are being used for many applications in smart phones and other products, such as face recognition and range finding. They are easier and cheaper to manufacture, test and assemble than traditional lasers.

Some VCSEL sources have a wide angle beam, making them challenging to measure - this issue is addressed by our various integrating sphere products incorporating photodiode sensors. Other VCSEL sources can be measured directly using the regular Ophir PD300 photodiode sensor series. In either case, the photodiode sensor needs to connect to one of the wide range of Ophir devices or meters in order to allow measurements to take place.

One of the main challenges created by VCSEL sources is that many of them emit pulses or bursts of pulses ranging from below 1ms to a few milliseconds in length, at fixed frequencies between ~10Hz and ~40Hz. These pulses are difficult to measure with existing equipment due to issues of synchronization, beating, saturation and measurement resolution. Using the regular power mode (designed for measuring CW sources) often the measurement is noisy due to beating of the pulse frequency with the sampling rate inside the electronics. As the amplifier gain used in the electronics is normally chosen to accommodate CW sources, when measuring pulsed sources the electronics can easily saturate due to the high peak power levels during the short pulses. In addition, whereas a higher power scale (with lower sensitivity) is required to accommodate the high peak power levels, the average power being measured is often very low compared to the peak power due to low duty cycle of the laser source. Therefore the measurement may suffer from lower resolution, higher noise and worse zero offset errors than would be the case when measuring a CW signal.

Figure 1:



All these issues are addressed by the new “Low Freq. Power Mode”.

How does it work?

When switching to “Low Freq. Power Mode” the firmware inside the device makes several changes to the way the electronics is configured and how it measures the photodiode signals, to accommodate the low frequency pulses being measured.

The sampling time used in the electronics is adjusted to match the pulse frequency in such a way that beating between them is avoided. The user needs to provide the pulse frequency, and the firmware adjusts itself accordingly.

The amplifier gain is adjusted to lower values to accommodate the expected high peak power levels. The output measurement resolution is expanded to 7 significant digits (in place of the regular 4 digits used in regular CW Power Mode) to accommodate the low average power relative to the chosen power scale.

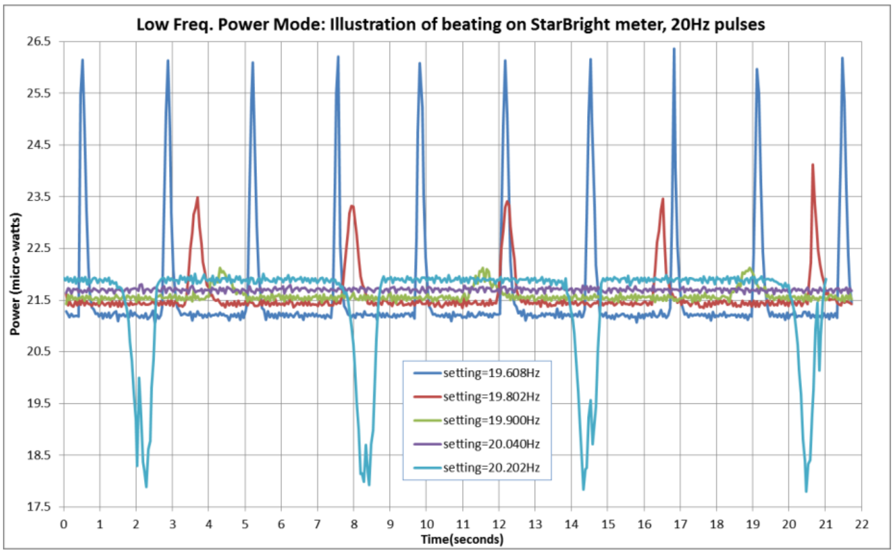
Some tips when using “Low Freq. Power Mode”

Zeroing:

Pay special attention to zeroing of the sensor. Zeroing is always critical, but even more so when measuring low duty-cycle pulses. When measuring CW sources the amplifier can be adjusted to the maximum possible gain to keep noise as low as possible, but when measuring short pulses the gain has to be reduced to accommodate the short peak powers. This results in more sensitivity to errors in zero levels that can cause more significant errors than when measuring CW sources. Always zero the sensor in the same environment as will be used when taking measurements. Preferably block out all background light - or at least reduce it to insignificant levels compared to the measurement being performed. Remember, a significant amount of background light might cause the zeroing function to fail, so block out as much as possible before starting.

Perform zeroing in the regular way as described in the user manual or documentation of the device. Remember to “save” the zero levels into the memory of the device when zeroing is completed.

Figure 2:



Choosing a suitable frequency setting:

Sometimes, if the laser pulse frequency does not quite match the sampling time being used by the software, beating effects can happen. This will manifest itself by periodic changes in the measurement, sometimes over a period of several seconds or 10's of seconds. If the frequency setting is too low, this may result in periodic positive "spikes" of power above the average power level being measured. If the frequency is too high, the spikes will be negative, below the average power level. As the frequency is adjusted closer to the correct laser frequency, the spikes will become smaller and further apart, until they disappear altogether when the frequency is adjusted perfectly. Note that due to slight errors in the nominal internal clock frequency of the measurement device, or of the laser pulse frequency, the exact frequency setting required for perfect measurements may not be exactly as expected.

In the illustration above (*Figure 2*), the exact frequency of the pulses appears to be 20.04Hz. Setting a frequency slightly above or below this value gives rise to spikes of power readings above or below the nominal average power. In addition, the nominal average power level (the flat sections between the spikes) appears to vary slightly with the frequency setting. The reason for this is that the overall average power (including the spikes) is constant in all cases, but the positive spikes are "offset" by a slight lowering of the "floor" level of the measurements, so that together they average out to the same average value in all cases.

Choosing a suitable power scale:

In general the most sensitive power scale should be chosen that does not show "over" on the display, indicating some kind of saturation. The firmware will notify the user when saturation is taking place, allowing the user to choose a less sensitive power scale when required. Note that sometimes the electronics may saturate (show "over") at lower levels of average power than the power scale could theoretically accommodate. For example, if choosing the 300uW scale, it is possible that "over" will be shown when measuring only ~100uW average power - it depends on the exact combination of duty cycle of the pulsed source, the internal power scale chosen automatically by the firmware, the laser wavelength chosen in the software, and other factors. The important thing to note is that the firmware will tell the user when a less sensitive scale needs to be chosen.

In addition, if the average power exceeds the maximum allowed by the chosen scale, for example 350uW on the 300uW scale, the message "OVER" (upper case) will be shown instead of "over" (lower case). This is a convenient way for the user to understand what the problem is causing the saturation.

Auto-ranging is disabled when using this mode.

Noise:

As described above, when measuring pulsed signals with low duty cycle, the chosen power scale needs to be less sensitive than would be optimal for a CW signal of similar average power. This potentially leads to higher noise than would be the case for an equivalent CW signal. In addition, due to the unstable nature of the signal being measured, higher noise is still inevitable. While the "Low Freq. Power Mode" will improve overall performance relative to the regular power mode, a certain increase in noise is still likely to be observed. In some cases it may be possible to reduce noise by averaging power measurements over a longer period.

When to use the Low Freq. Power Mode:

Sometimes the hardware may provide sufficient low pass filtering to smooth out peaks of power caused by the pulsed signals, thereby improving performance and reducing noise. Low pass filtering can vary from ~160Hz (1ms response time) for the least sensitive analog ranges, ~2Hz (86ms response time) for moderate sensitivity ranges, and down to ~0.64Hz (250ms) for the most sensitive ranges. The internal range is chosen automatically by the firmware when selecting a power scale. When an analog range with heavy low pass filtering is selected, using the regular power mode may sometimes be a better choice than selecting the "Low Freq. Power Mode" where a less sensitive analog range may be selected automatically.

The following steps are recommended:

1. First try selecting regular "Power" mode.
2. Choose the most sensitive scale possible that does not cause "over"
3. Observe the power measurements to determine if the data is stable or noisy
4. If the signal is very noisy, switch to Low Freq. Power Mode.
5. If the data is stable, change up by one power scale (for example, from 3uJ scale to 30uJ scale)
6. Check the average power measured is the same on successive power scales - if not, that might indicate saturation on the more sensitive power scale. In that case, switch to Low Freq. Power Mode.

For photodiode sensors with a "Filter IN" option, in some cases it may be better to use the additional filter and set the Power Meter to "Filter IN" option, thereby reducing the signal on the photodiode and forcing the firmware to choose a more sensitive internal analog range which has heavier low pass filtering. This may provide better performance for pulsed signals.

Devices and meters supporting the "Low Freq. Power Mode":

Many Ophir "meters" (with LCD displays) and "devices" (with direct connection to PC via USB or Ethernet) will be offering the Low Freq. Power Mode. These include the StarBright and Centauri meters; and the Juno and EA-1 devices. Ophir's "StarLab" PC application will support all these meters and devices. Some OEM sensors will also be offering a similar solution. Introduction on the various platforms is planned for Q2 2019.

For more details on this subject, or questions on any other topic, please contact your local sales rep or fill in a request form on-line on our website: www.ophiropt.com