Clean Jump Performance Update

Application note for PPCL700, status 11 December 2021

This note describes the current status of the Clean Jump functionality on the PPCL700. This functionality is now considered mature, but there is ongoing activity to improve the performance.

The current timestamp of the module is 47.118. All later firmware versions will have this version or improved versions. The timestamp of the module can be retrieved by probing the release register. The output would be ‘PV 3.0.0:HW 3.0.0:FW 7.0.1:AS C1:TS 047.118.0’, with the information after the TS being the timestamp.

Note, compared to earlier versions, we are not compensating the frequency setpoint for the ambient temperature during the Clean Jump. This means that previous calibrations with earlier firmwares are not valid anymore and will need to be redone.

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1. Test results

A device was calibrated at 225 point with spacing of 20 GHz, starting at 191.5 THz (i.e. covering most of the C-band) and output power 13.5dBm.

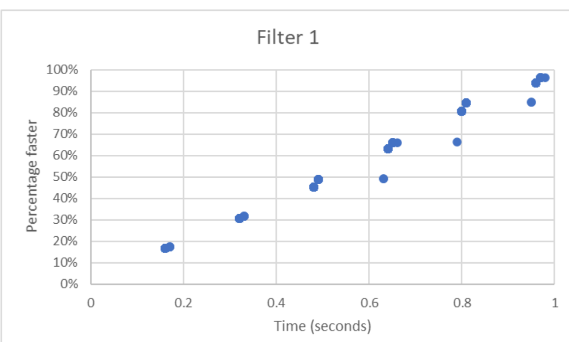
3 sequences of 500 Clean Jumps were started and the data was collected over 10 seconds after each jump. The data was analyzed to determine the switching speed for each filter and the time it took for the device to be in the final optical mode and to be within 0.5 and 0.2dB from target. Note that when the device is in the final optical mode, the frequency is within 3GHz from target. A 0.7dB offset from the target power is about a 2GHz offset from target.

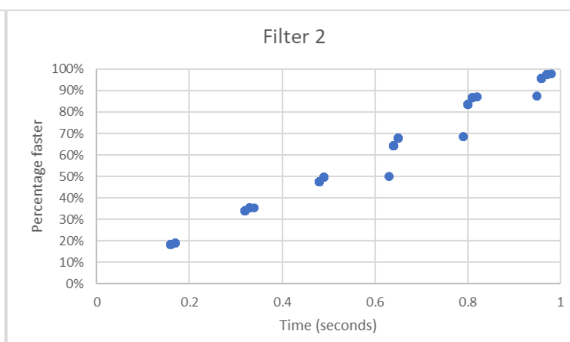
Clean Jump Completion rate

Of the 1500 jumps, 1496 resulted in a successful clean jump (>99.5%). A failed clean jump hence can't be completely avoided and can be recognized by an output power well below the target (typically off by 3dB).

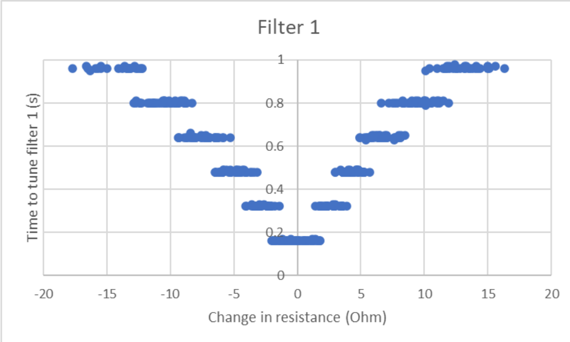
Filter switching time

The jumping sequence is that first the filter elements (2) are set to the target value. After that the phase element is adjusted to align the cavity mode with the filters. Hence with faster switching time for the filters, the phase lock effort can be started faster and completion of the jump is faster. The below two graphs show the switching time for each filter (very similar, discretization of time is due to RS-232 communications interval). Close to 100% of the filter changes are realized within 1 second with the majority taking much less.





Plotting the switching time versus the change in resistance, once can see that there is a clear correlation. Hence, by picking the right combination of current frequency and target frequency the switching time can be optimized.

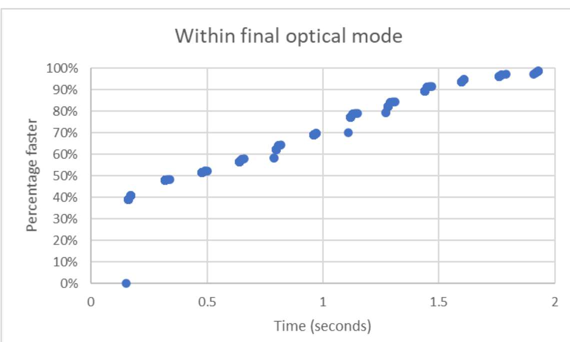


Note that the switching time for the filters is dependent on the amount of change in resistance. Hence it is possible to predict the switching time for the filters. Where the phase section ends up at the end of that switch and how much it has to tune is less deterministic and more random.

Switching time to optical mode

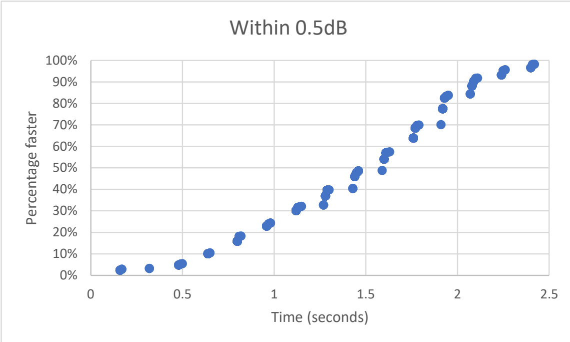
The most critical metric is how long it takes to get to the target optical mode. After reaching that optical mode, the power may still be off by 1 – 1.5dB, but the frequency will be within 3GHz from target.

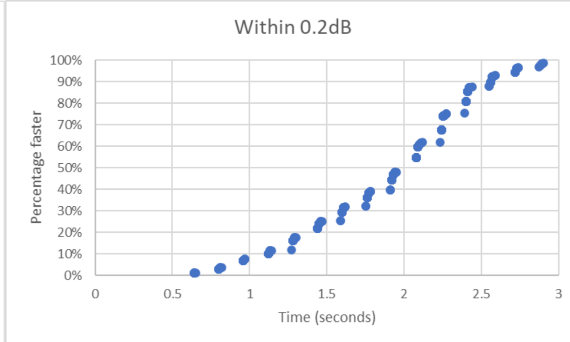
The below graph shows the switching time to reach the target optical mode. 40% of the jumps are within that mode within 200ms; 70% is within the mode after 1 second and after 2 seconds close to 100% is within the target optical mode.



Switching tine to target power

Once the laser is in the target optical mode its alignment with the filters will continue to improve and it will trend towards the target power. The below two graphs show the time it takes to get within 0.5 and 0.2dB from target.


Within 0.5dB
Percentage faster
Time (seconds)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
0.5
1
1.5
2
2.5


Within 0.2dB
Percentage faster
Time (seconds)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
0.5
1
1.5
2
2.5
3

2. Further work

The Clean Jump feature is still under development, and we intend to optimize the routine from where it is at now:

1) Increase the switching speed of the filters, especially when the resistance change is large
2) Engage the tuning of the phase section earlier so that part of that switching time overlaps with the tuning of the filters.
3) Gain better understanding of interactions between phase section and the filter sections during tuning (this is what forces us currently to first tune filters and then phase section) to be able to better speed up the phase section tuning.
4) Speed up the tuning of the phase section.