Clean Jump Implementation

Implementation Guide: Clean Jump

The Pure Photonics products provide a very low frequency noise, making them very suitable for sensing applications. In that low-noise mode, the Pure Photonics firmware adds frequency flexibility, so that the laser can be quickly moved from one frequency to another. Dependent on the distance of the temperature setpoint for the beginning and ending frequency point, the switching time can be as fast as 0.1 seconds or as slow as 1.0 seconds.

Frequency jumps in low multiples of 15GHz and multiples of 275GHz are most suitable for fast switching (typically <0.2 seconds). In addition, frequency set points that require little change in the temperature setpoint of the sled are more favorable for speed.

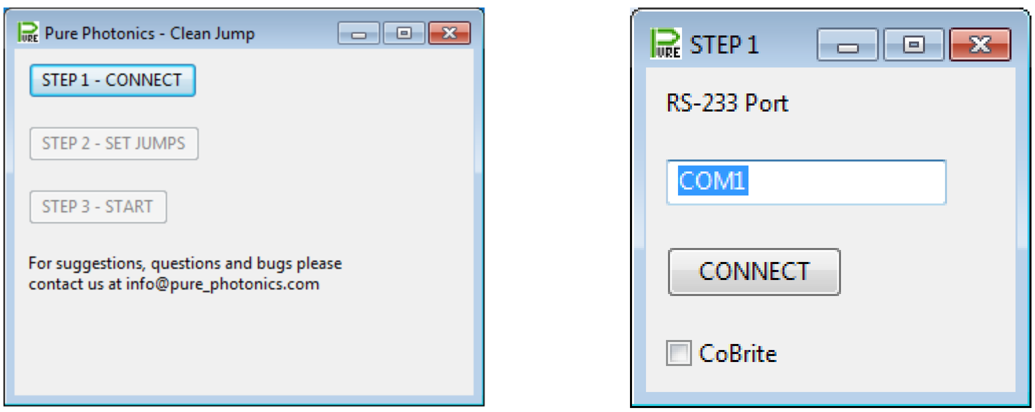
This implementation guide describes how to operate the Clean Jump, both in the Graphical User Interface and at the RS-232 interface level.

1. Graphical User Interface

The Graphical User Interface (GUI) is a convenient means to experiment with the Clean Jump interface and to do initial experiments. We do anticipate that for real-life applications, most user will want to have more functionality and would opt for implementation in their own custom application. If you are not comfortable with programming your own application, please contact Pure Photonics for assistance.

The GUI can be downloaded from the Pure Photonics website (www.pure-photonics.com) and will contain an executable file ('PP GUI.exe') and several .bat files. Activate the Clean Jump GUI by double-clicking 'PP GUI Clean Jump.bat'.

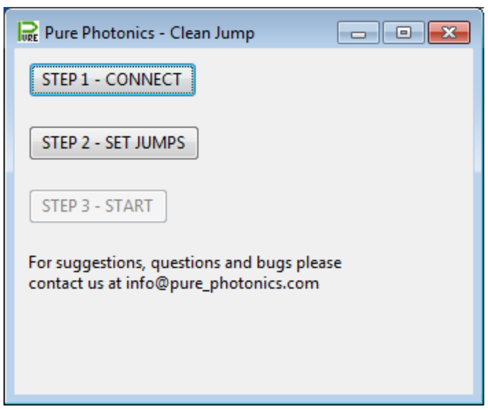
A screen will show with 'STEP1', 'STEP2' and 'STEP3' buttons. Only 'STEP1' is selectable. Press this button and indicate the COM port where the laser is located (e.g. COM1). If you are using a CoBrite product, select the 'CoBrite' selection box. Note that the program works best with COM-port IDs below 10. If the COM port ID is higher, then please use the Windows Hardware Manager to adjust the COM port ID.

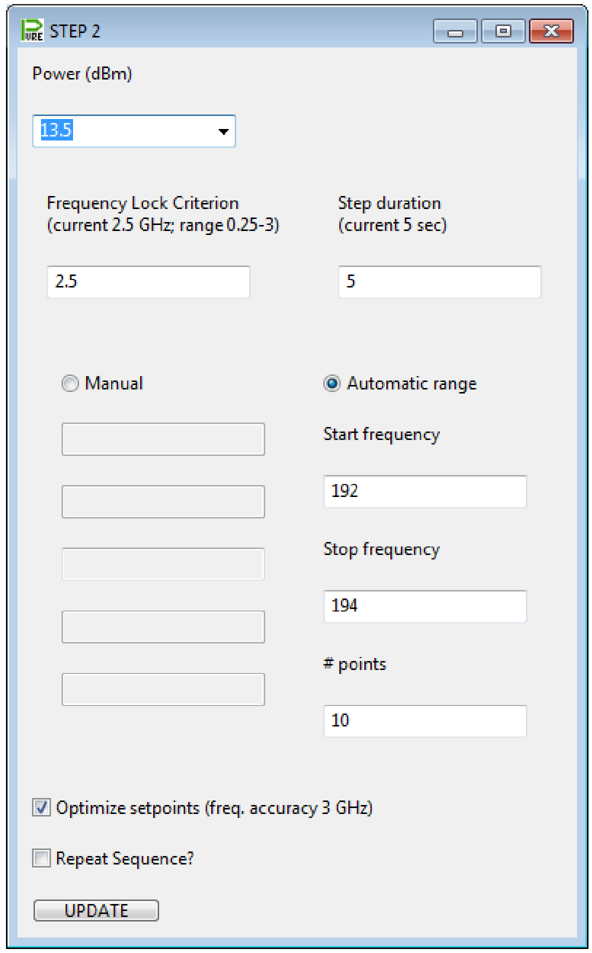


Opening screen of Clean Jump GUI (left). 'STEP1-Connect' screen (right)

After the contact with the laser is established, the 'STEP2' button will become available. Press 'STEP2' and select the following parameters:

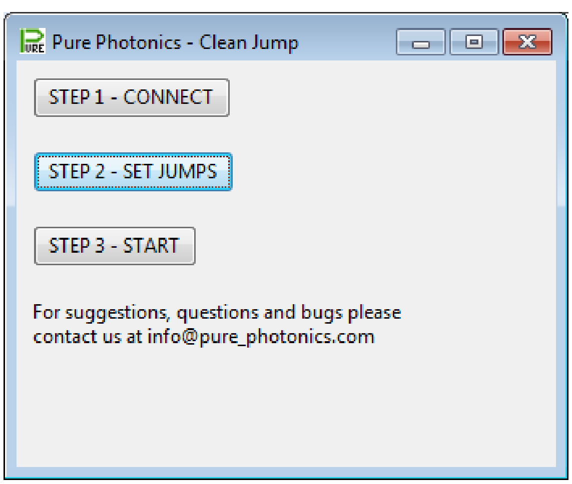
- Output power (requires the map file for that power level to be present)
- Frequency lock criterion (lock is established if the frequency is within this range from the target)
- Step duration (time the GUI stays at the target frequency after lock, before moving to the next point)
- Type of frequency jumps
    - Manual: sequence of frequency points to jump to
    - Automatic range: use equidistant points within a range to jump to
- Optimize setpoints: optimize/shift the target frequency points to ensure that the sled temperature remains equal between the jumps (this guarantees more smooth and faster jumps)
- Repeat sequence: repeat the chosen sequency five times





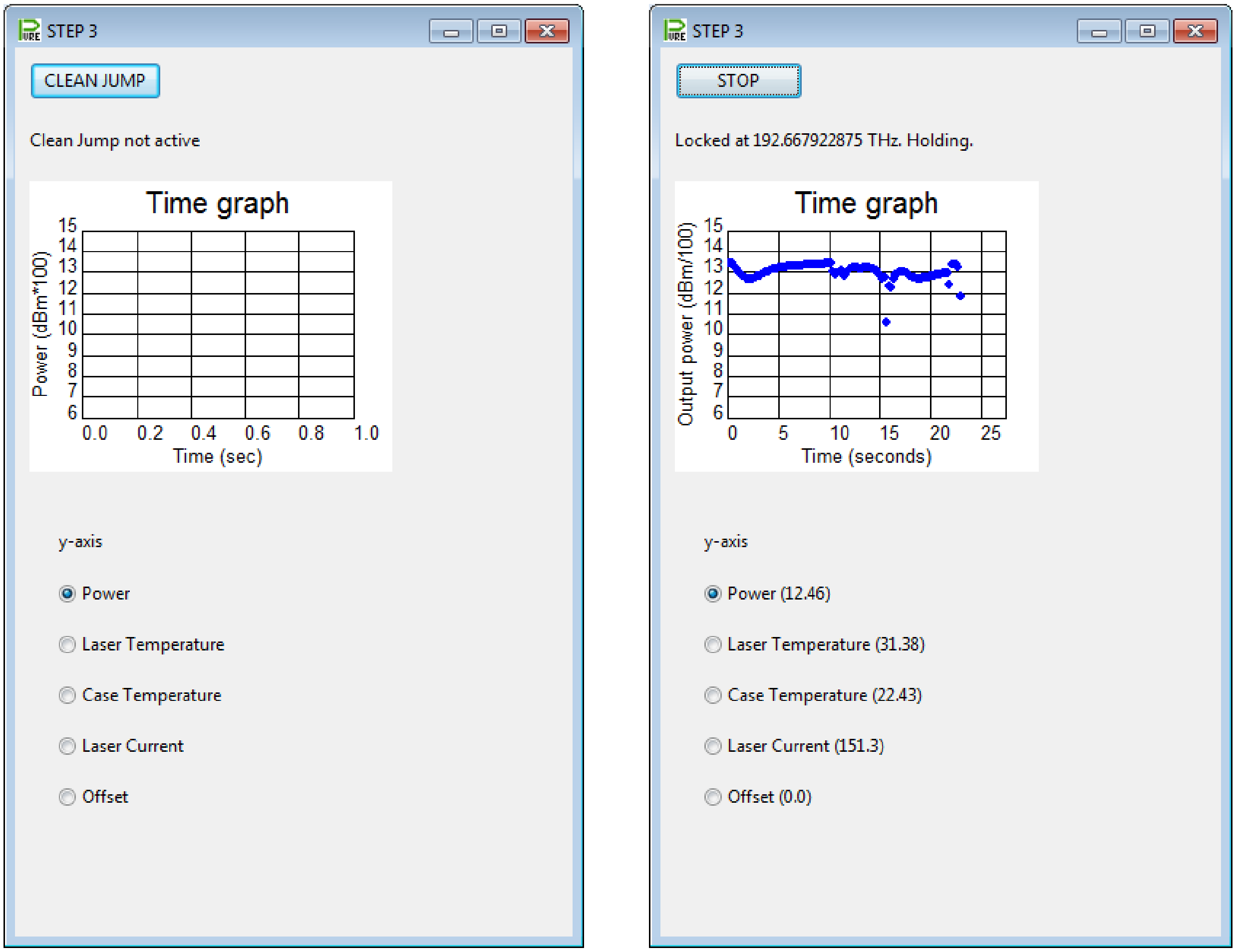
Main screen after connection to laser (left) and 'STEP 2' screen

After pressing update, the sequence is verified and the setpoints are created. If all information is valid, the sequence is accepted and the 'STEP3' button is activated. Otherwise and error message will show.



Main screen after setting clean jump sequence

Press the 'STEP3' button to activate the graph interface. Pressing the 'CLEAN JUMP' button will start the Clean Jump sequence. The Clean Jump sequence can be interrupted by pressing the 'STOP' button.



'STEP3' window during Clean Jump sequence

During the Clean Jump sequence, the laser will jump to each frequency in the sequence and lock at the correct setpoints. It will determine the frequency offset from its target and once it is within the locking target, it will remain at the set point for the waiting time. After that it will jump to the new target. This is all indicated next to the button. Note that when the frequency is locked and it overshoots (i.e. it loses lock) the timer is restarted when lock is obtained again.

2. RS-232 interface

The RS-232 interface follows the conventions, as outlined in the OIF-MSA (http://www.oiforum.com/wp-content/uploads/OIF-ITLA-MSA-01.3.pdf). Several registers have been added to enable the Clean Jump functionality.

On the next page the flow-chart for the Clean Jump function is given. It requires firmware version 8.1.x or 8.0.9 and assumes that the user has the calibration files '.li', '.sled' and '.map'.

The basic flow is to turn-on the laser and to sequentially jump to the next setpoint, while monitoring the frequency offset until the frequency has stabilized.

Flow Chart

	Activate the laser			
	↓			
	Set laser to starting frequency	0x35	e.g. 190	THz part
		0x36	e.g. 9000	10*GHz part (in this case 190.9THz)
	↓			
	Turn laser on	0x32	8	SENA bit 3 = 1
	↓			
	Monitor NOP until laser is locked	0x00		Pending flags in bit 9-16
	↓			
	Turn on Low-noise mode	0x90	1	Activate the Clean Mode 1
	↓			
	Set next frequency (THz part)	0xEA	e.g. 193	THz part
	↓			
	Set next frequency (GHz*10 part)	0xEB	e.g. 6785	10*GHz part (in this case 193.6785THz)
	↓			
	Set next sled temperature (C *100)	0xEC	e.g. 3134	to move the sled to 31.34C
	↓			
	Set next drive current (mA*10)	0xE9	1323	to move the current to 132.3mA
	↓			
	Hold laser for desired time			
	↓			
	Initiate Clean Jump (1)	0xED	1	transfer frequency, temperature and current to memory
	↓			
	Initiate Clean Jump (2)	0xED	1	calculate filter 1
	↓			
	Initiate Clean Jump (3)	0xED	1	calculate filter 2
	↓			
	Initiate Clean Jump (4)	0xED	1	Execute the jump
	↓			
	Monitor error until within range	0xE6		Coded as error = (value - 10000)/10 GHz
	↓			
Yes	**Next setpoint ?**			
	↓			
	No			
	↓			
	Stop Clean Jump	0xED	0	

The parameters for the Clean Jump are obtained from the different calibration files. These calculations can be performed real-time or can be pre-calculated for a specific frequency trajectory (depends a bit on the system where it is going to be implemented).

For each setpoint the following values are needed: frequency, sled temperature and drive current. It is recommended to also perform the calculation of the filter1 and filter2 setpoint, because, even though the laser performs that calculation, it prevent an incorrect determination of the sled temperature in some rare cases.

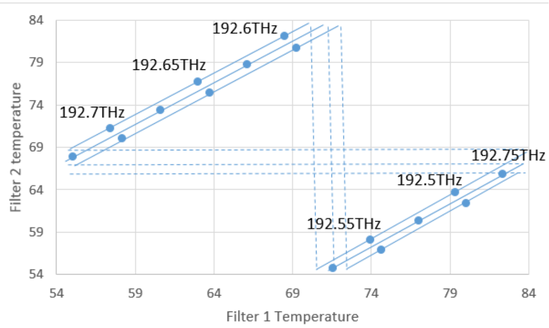
Filter1 and Filter2

The '.map' files contain the set-points for filter1 and filter2 at a specific grid (typically 50GHz grid). The setpoints at a specific frequency can be obtained by interpolation. However, one needs to be careful for discontinuities.

Say the target frequency is f_{target}. Then two grid points can be selected grid1 with the closest lower frequency and grid2 with the closest higher frequency. If the filter temperatures for the grid2 point are both lower than the filter temperatures for the grid1 point, then there is no discontinuity and a simple interpolation can be used.

If this condition is not met, a discontinuity is present. In that case, it is recommended to extrapolate to the f_{target} with the two next grid points with lower frequency and the two next grid points with higher frequency (make sure for both extrapolations that there is no discontinuity between those two points). Select the calculated setpoint with filter temperatures closest to 69 degrees C.

In the below graph the filter1 and filter2 setpoints of the grid are shown for a specific laser. The dots are the points in the '.map' file. The solid line indicates the continuous frequency and the dotted lines show how those lines are connected (no valid setpoints on the dotted lines). The line can be followed starting at frequency 192.5THz. Between 192.55THz and 192.6THz there is a discontinuity. And again between 192.7THz and 192.75THz.



In this example, e.g. frequency 192.53 can be calculated with normal interpolation. Frequency 192.56 needs to be extrapolated from setpoints 192.5 and 192.55THz. Frequency 192.595 needs to be extrapolated from setpoints 192.6 and 192.65THz.

Sled temperature

The sled temperature needs to be extrapolated from the closest grid frequency setpoint, that was used in the calculation of the filter1/filter2 setpoints (i.e. referring back to the example in the previous section, for 192.53 use 192.55; for 192.56 use 192.55 and for 192.595 use 192.6. The sled temperature is calculated with the 'sledslope' in C/GHz (typically about -0.23 C/GHz). This value is either obtained from Pure Photonics for the specific unit, or can be read from register 0xE8 in units of 0.0001 C/GHz.

The allowed sled temperatures for a specific frequency set point are spaced 3C apart. It may be that the one that was calculated is not the most appropriate for the Clean Scan. To correct it the temperature needs to be changed in steps of about 3C to be similar to the previous sweep. The mode-spacing can be obtained from the '.sled' file.

The '.sled' file contains clusters of valid sled temperature values (for a specific frequency), spaced by approximately 3 degrees C. The values in the '.sled' file should be used to calculate an accurate mode distance. The easiest way is to assign integer values to the clusters and then do a linear fit. Alternatively, you can take the average of each cluster and then simply take the average of the distance between clusters.

With the example of 23.23C and a mode spacing of 2.97 C, the value 23.23 + 2*2.97 = 29.16 is the closest mode to 30C.

Drive current

The '.map' file contains the drive current. A simple interpolation will suffice.

Adjustment to one common center point temperature

To optimize speed and efficiency of the switch between sweeps, it is recommended to make the sled temperature of the center point the same between sweeps. After calculation of the center-point based on the desired grid, it can be offset by a specific temperature, as long as the filter1 and filter2 values are also changed.

For example, if the calculated sled temperature is 29.16C and the target is 30C, the sled temperature is raised 0.84C and the frequency is lowered by (0.84 divided by a sledslope of e.g. 0.23C/GHz) 3.65GHz.

Now, the filter1 and filter2 set points also need to be adjusted by this frequency to maintain alignment of the tuning elements. The filter1 and filter2 slope can be obtained from the '.map' file. As discussed before, ensure that you use two setpoints that are continuous. The filter1 and filter2 slope can be calculated by dividing the temperature difference by the frequency difference (typically 50GHz). The value should be around -0.11 C/GHz. For the 3.65GHz offset in the example, the filter1 and filter2 setpoints should be adjusted by (assume -0.1065 and -0.1080 for filter1 and filter2 slope) 0.389C and 0.394C, respectively. The temperature change of sled, filter1 and filter2 should all go in the same direction.