(Extended) Clean Sweep

Implementation Guide: (Extended) Clean Sweep

The Pure Photonics products provide a very low frequency noise, making them suitable for sensing applications. In that low-noise mode, the Pure Photonics firmware adds frequency flexibility, so that the laser can be swept in a single optical mode over a certain range in single-mode operation and with very low noise.

With the Clean Sweep feature sweep ranges up to 250GHz are available (for properly selected and calibrated devices). For ranges beyond 150GHz, the control mechanism is altered to ensure proper operation and the device requires some additional calibration data to be fed. We call this the Extended Clean Sweep operation.

This implementation guide describes how to operate the Extended Clean Sweep, both in the Graphical User Interface and at the RS-232 interface level. **The standard Clean Sweep would be implemented in the same way, but without the additional calibration constants.**

1. Extended Clean Sweep

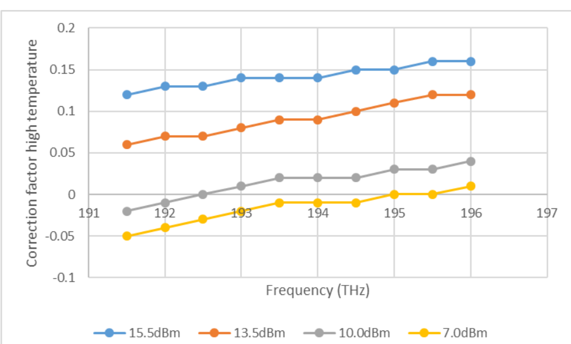
The clean sweep within the Pure Photonics laser is based on temperature control of the tuning elements in the laser. By simultaneously controlling the three tuning elements, the optical mode can be moved around in a controlled, single-mode manner. For frequency ranges of up to 150GHz (+-75GHz), corresponding to about 35C temperature variation of the lase, the built-in calibration parameters will suffice. For ranges beyond the 150GHz, up to 250GHz (60C temperature range), additional feedback is needed.

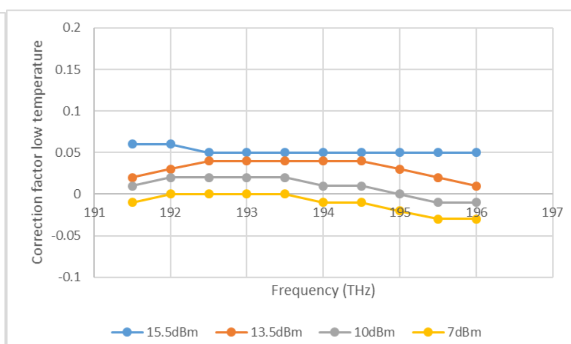
For a 250GHz sweep, the temperature of the laser will vary over about 60C range. This is a very wide range for any semiconductor laser, especially if the laser needs to remain single mode. To ensure that stability, the laser current is fixed as a function of temperature, so that no feedback loop is needed. In addition, the direction of the sweep at the extremes can be fine-tuned by two correction factors (one for the low temperature extreme, one for the high temperature extreme).

Within the GUI, the .csmap file is uses (filename is serialnumber.csmap) to get the drive current versus the temperature and the program will feed that to the laser. The correction factors are somewhat setup dependent and the user can set those in the STEP 2 window.

For direct RS-232 control, the user will need to provide the calibration data to the laser. The method is described in section 3.

The two correction factors are experimentally determined and are dependent on the user configuration, such as heatsinking etc. Pure Photonics may provide a starting point for these parameters, but some finetuning may be needed in the user setup. Below is an example of how these parameters typically vary. Naturally, any specific device may behave differently.





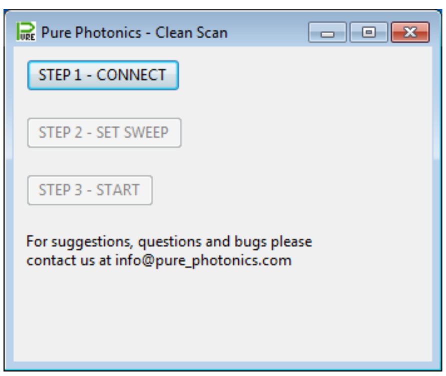
2. Graphical User Interface

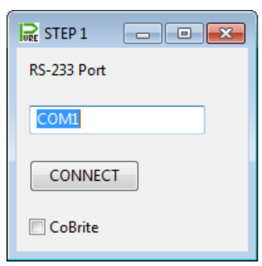
The Graphical User Interface (GUI) is a convenient means to experiment with the Extended Clean Sweep interface and to do initial experiments. We do anticipate that for real-life applications, most user will want to have more functionality and would opt for implementation in their own custom application.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

Note that the GUI suite both contains the Clean Sweep GUI and the Extended Clean Sweep GUI. To make use of the additional calibration data, the Extended Clean Sweep GUI needs to be used. In case the standard Clean Sweep GUI is used for frequency ranges beyond 150GHz, one can expect undesirable mode-hops at the extremes of the sweep.

The GUI can be downloaded from the Pure Photonics website (http://www.pure-photonics.com/downloads1/) and will contain an executable file ('PP GUI.exe') and several '.bat' files. Activate the Clean Sweep GUI by double-clicking 'PP GUI Clean Sweep Extended.bat'. The calibration data (a file with extension '.csmap') is obtained from Pure Photonics for units that have been calibrated and configured for extended range.

A screen will show with 'STEP1', 'STEP2', 'STEP3' and 'STEP4' 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.





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

After the contact with the laser is established, the other buttons will become available. Press 'STEP2' and select the center frequency, sweep range, power level, sweep speed and correction parameters (see previous section). Select 'Update' to save the settings.

Now select 'STEP3' and press 'Enable Laser'. This will enable the laser and once the laser is stable, the button for 'Enable Sweep' will become available. Upon pressing this button, the laser will move to the whispermode and the sweep will start. Pressing the button again will disable the sweep.

At any time 'STEP4' can be pushed to monitor the laser performance. A graph will appear with the desired parameter versus time.

3. 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 Sweep functionality.

Below the flow-chart for the Extended Clean Sweep function is given. It requires firmware versions 8.0.x. For sweep ranges that are more than 150GHz we recommend to have the calibration file '.csmap'. These files can be used as-is or in some way embedded within the user application. Only version 8.0.9 and later have the standard sweep and the extended sweep integrated in one firmware version. **For sweep range < 150GHz, no calibration constants need to be uploaded to register 0xF7 (standard Clean Sweep).**

The basic flow is to turn-on the laser, enable the whispermode and to start the Clean Sweep. The Clean Sweep will continue indefinitely until it is terminated or put on hold. If the sweep is put on hold it can be re-activated or terminated. After termination the frequency goes back to the center frequency.

Flow Chart

	Step		Register	Value	Comment
	Activate the laser				Turn on power supplies
	↓				
	Set laser to starting frequency		0x35	e.g. 190	THz part
			0x36	e.g. 9000	10*GHz part (in this case 190.9THz)
	↓				
	Set Scan range		0xE4	250	To set the scan range to 250GHz
	↓				
	Set Scan Speed		0xF1	20000	To set the scan speed to 20.000 GHz/sec
	↓				
	Set power level		0x31	1300	To set to 13dBm
	↓				
	Set Channel to 1		0x30	1	To make sure that the laser comes on at FCF (as set in 0x35 and 0x36)
	↓				
SKIP FOR SWEEP < 150GHz	Upload calibration values (11x)	**11x**	0xF7	see table	Upload the 11 calibration values (**this always needs to be 11 consecutive commands)**
	↓				
	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
	↓				
	Wait 0.5 seconds (recommendation)				
	↓				
	Turn on the Clean Sweep		0xE5	1	Turn the Clean Sweep on. Laser will start increasing the frequency
	↓				
	Read offset		0xE6		Keep the Clean Sweep going until done
	↓				
	Keep going?				
	↓ Stop				
	Stop Clean Sweep		0xE5	0	
	↓				
	Exit Low-noise mode		0x90	0	
	↓				
	Disable laser		0x32	0	

Extended sweep parameters

The '.csmap' file contains the setpoints of the laser versus temperature for different frequency and power setpoints. For any given frequency and power setpoint, this dataset needs to be interpolated to get the operating current at device temperatures -10, 0, 10, 20, 30, 40, 50, 60 and 70 degrees C. Any desired interpolation method can be used as the underlying data is supposed to be continuous. Dependence on frequency is small, whereas dependence on power level can be strong.

A screenshot of a .csmap file is shown. The data is ordered by frequency and power. The columns are (in order): frequency (in THz), target temperature (in 0.001 C), power (in 0.01dB), actual temperature (in 0.01 C), sled temperature (in 0.01 C), TEC current (in 0.1mA), drive current (in 0.1mA). Only the 1st, 3rd, 4th and 7th column are required for the extrapolation.

The recommended extrapolation is to first calculate the datapoints versus temperature (either at the target frequency and power or at the higher and lower frequency and power) and then to extrapolate to the right power level and then to the frequency.

```
191.5 48010 700 4689 2504 62231 915
191.5 51010 700 5011 2540 61786 987
191.5 54010 700 5330 2575 61476 1069
191.5 57010 700 5639 2613 61041 1167
191.5 60010 700 5945 2649 60585 1286
192.0 10 700 -422 2287 7673 503
192.0 3010 700 201 2304 5494 502
192.0 6010 700 520 2317 4233 507
192.0 9010 700 842 2330 3531 514
192.0 12010 700 1164 2343 2596 525
192.0 15010 700 1492 2357 2190 539
192.0 18010 700 1820 2372 1377 556
192.0 21010 700 2150 2388 572 578
192.0 24010 700 2482 2408 65469 603
192.0 27010 700 2483 2405 65526 603
192.0 30010 700 2815 2427 64939 634
192.0 33010 700 3149 2451 64355 671
192.0 36010 700 3481 2470 64130 713
192.0 39010 700 3809 2493 63468 760
192.0 42010 700 4138 2522 62835 812
192.0 45010 700 4463 2548 62610 870
192.0 48010 700 4786 2577 62333 937
192.0 51010 700 5103 2607 61601 1016
192.0 54010 700 5418 2637 61572 1113
192.0 57010 700 5731 2670 61137 1234
192.0 60010 700 6030 2703 60877 1378
192.0 63010 700 6319 2735 60480 1554
192.5 10 700 -31 2331 5989 478
192.5 3010 700 277 2338 5052 483
192.5 6010 700 595 2346 4196 491
192.5 9010 700 924 2358 3278 502
```

The parameters are provided to the laser through register 0xF7. It is important to always feed 11 values to this register at a time. Otherwise the internal counter may get out of sync (and there is no method to resync). The first 9 values are the drive current at -10, 0, 10, 20, 30, 40, 50, 60 and 70 degrees C in units of 0.1mA (e.g. 2000 for a target drive current of 200mA). The last two value are the correction factors. The 10th value is the high temperature correction factor and the 11th value is the low temperature correction value. In units of 0.01 (i.e. 0.12 is sent as 12). Note that these last two values are signed integers. So -0.06 would be send at -6, which would be 0xFA (250).