Amplitude Modulation

Application note: AM input

The PPCL300 and PPCL550 Pure Photonics tunable laser (and some custom partnumbers) can be optionally configured with an amplitude modulation input. This input can be used to modulate the power at up to 1MHz and/or realize associated frequency modulation.

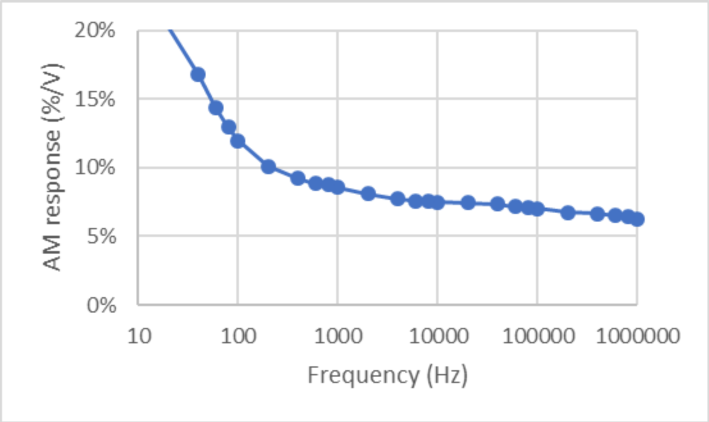
This application note describes the amplitude modulation feature.

1. Configuration

The AM input is an analog input into the gain current driver circuit. On PPCL300 it is pin 16 of the 20 pin connector. On the PPCL550 it is the first SMA connector from the corner.

The AM input is a high resistance input (20kOhm) without noticeable current draw. The useful input range is 0-10V. We don't recommend operating outside of this range, but in most cases, it will be possible to operate. If the voltage is too high, the drive current on the chip may get too high, resulting in inefficient operation and/or roll-over. If the voltage is too low, the current may be driven below threshold and the laser may shut-off.

A typical amplitude modulation response is shown in the below graph. This may vary from device to device, but the general characteristics apply. This test was done at 13.5dBm, but one would expect the response to be stronger at lower power level. The bandwidth o the modulation is 1MHz (assuming the low RIN circuit is not present).



Dither / telecom mode

In dither/telecom mode the laser tries to control the drive current to obtain a certain output power. The change of the AM input voltage will drive the current away from the equilibrium point and the module will respond by pulling it back. For frequencies above 100Hz, the module will have difficulty to respond and one can modulate (the higher the frequency, the higher the amplitude), without affecting the equilibrium point.

When applying a modulation signal that is moderately strong and/or close to 888Hz, the laser will lose lock and go in thermal run-away.

Whisper mode

In whisper mode, the laser has disabled the dither and the laser is not dependent on the locking signal. As such, the user can apply any signal on the FM input without impacting the locking behavior of the laser.

2. Test report: AM Modulation & FM response

The tests in this report are performed on CRTNGCE00M PPCL300 unit in PPCL550 module with AM modulation input. The standard circuit configuration for the AM modulation is used.

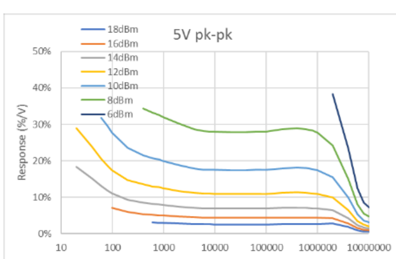
Tests were performed over the frequency range 20Hz to 10MHz. At begin of testing the AM modulation input was connected and set to an appropriate DC voltage (1V for most of the testing; we found that setting the voltage too high prevented the unit to be able to activate at lower output powers). The AC modulation was set to 2 mV and the frequency was set to 10MHz. The unit was started up at 193.41THz (1550nm) and after startup the power onto the detector was controlled to give a 3V output voltage.

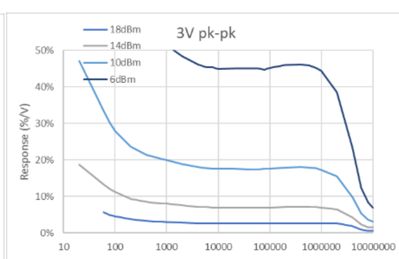
Then the unit was put in whispermode and the AC frequency and voltage was varied according to the testing requirements. Tests with 5V pk-pk were done at 18, 16, 14, 12, 10, 8 and 6 dBm. Tests at 3V pk-pk and 1V pk-pk were done at 18, 14, 10 and 6dBm. Finally, tests were done with the power routed through an optical filter with a slope of 2.5%/pm FM to AM conversion ratio at 193.41THz. These tests were done with 3V pk-pk at 18, 14, 10 and 6dBm.

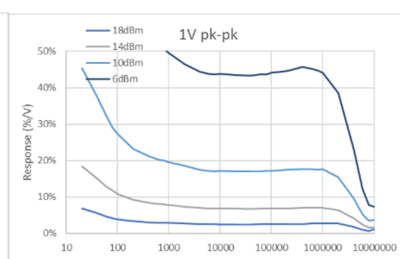
For each testing, an oscilloscope is used to capture the frequency generator signal and the photo-diode signal (both measured in AC mode). The signal is noise filtered and the pk-pk is derived. The response is derived as % photo-diode (pk-pk/DC level) signal per 1V of applied signal.

In the below graphs the response versus frequency is shown with 5V, 3V and 1V applied pk-pk voltage. It can be seen that some curves are not complete as some conditions drove the unit to non-linear and clipped behavior. It can be seen that the response at 1V pk-pk through 5V pk-pk is similar, indicating a fairly linear response (until clipping or other non-linearities are observed).

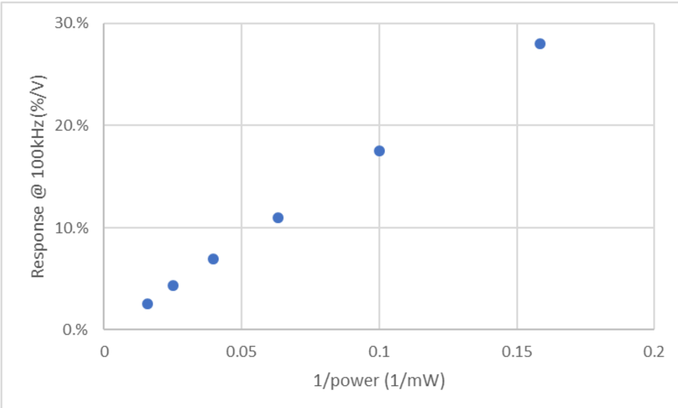
Also the bandwidth of the circuit can be seen. There is a roll-off starting at 1MHz. It has been observed that at 2MHz the response is 90degrees delayed from the stimulus. At 4MHz it is 180degrees and at 8MHz it is 360 degrees.



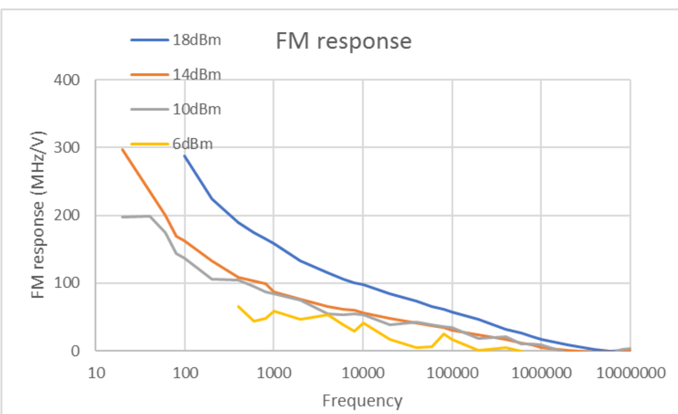




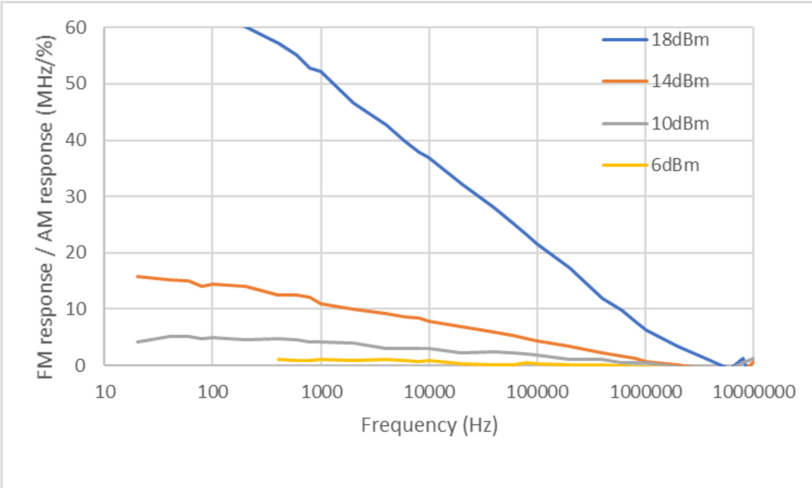
The response is in general consistent with the expectation. As the applied voltage is (in principle) linear with drive current, one would expect the response to be proportional to 1/power. In the below graph the response at 100kHz is shown versus inverse power, showing consistent behavior. As the denominator is the output power and the slope (in mW/mA) is constant, the response is stronger at lower power and the power can be changed to get to the desired behavior.



The signal through the optical filter is subtracted from the AM signal at the same settings. The resultant signal (in %/V) is then converted into a MHz/V response. Surprisingly the bandwidth type behavior seen in the AM response is not visible in the FM response. This is likely because the response at 1MHz and above is already very small and the response gets significantly stronger at lower frequencies. This progressively stronger effect at lower frequencies is likely related to a thermal response of the gain chip. In response to the modulation, the carrier density (and hence output power) responds fast, following the response of the electronics circuit. The optical length of the cavity (determining the frequency) is more dependent on the temperature of the gain chip and hence will have a slower response.



Finally, the FM and AM response are divided to get a MHz response per %AM modulation. This data shows that the FM response is smallest (per % AM modulation) at lower powers (i.e. best for pure AM modulation with minimum FM modulation) and strongest at higher powers (i.e. best for FM modulation with lower AM modulation).


60
50
40
30
20
10
0
FM response / AM response (MHz/%)
10
100
1000
10000
100000
1000000
10000000
Frequency (Hz)
18dBm
14dBm
10dBm
6dBm