VORTRAN LASER TECHNOLOGY, INC.

Stradus™ Modulation Operation

Overview:

Laser Diodes have the ability to be modulated by changing their drive current. This makes them ideal replacements for DPSS Lasers and other Laser types, when matching wavelengths are available. Telecom laser diodes have been modulated into the GHz range and are used today for Fiber transmission of data. The Stradus**™** is not able to be modulated at these frequencies, but we come close.

Stradus**™** has a variety of modulation operating modes and combinations of modes that will be explained. We will show examples of actual modulation traces for various wavelengths, including the Stradus™ 488nm-50mW which in the past could only be achieved by either a Gas Laser or DPSS Laser. These lasers, however, could not be easily modulated whereas the laser diode module can be modulated easily.

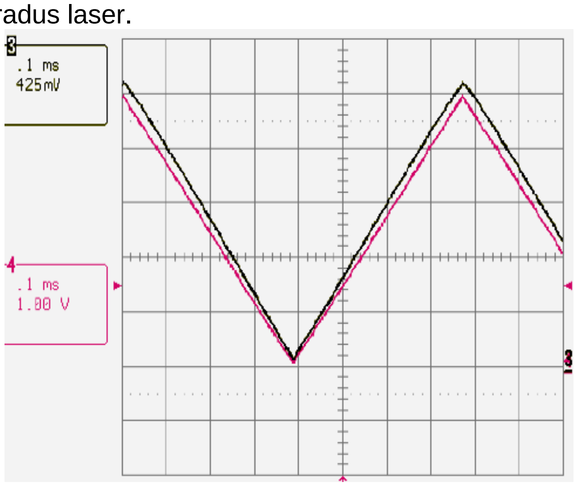
We have separated the Stradus™ operating modulation modes into two distinct modes; Analog and Digital. We will explain the operation of each and the operation of a combined mode.

Analog Modulation:

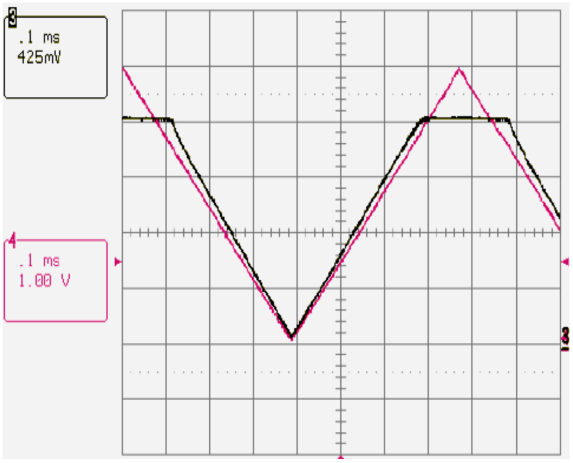
The Stradus™ uses light feedback to control the power output. Using the on-board microprocessor, the output power can be controlled from near 0mW to the maximum rated power of the particular Laser Diode. We do this by varying the control voltage to the light control feedback amplifier. The control voltage is compared by the amplifier to a fixed reference voltage, thus the full output power range of 0 to full power is represented by a voltage of 0 to the full reference voltage. We can then vary the reference and by definition the output power. The Stradus light control loop bandwidth determines the Analog Modulation bandwidth. The linearity and offset is defined by any error in the control amplifier, which is typically very small.

Stradus operation refers to Analog modulation as **External Power Control** or **EPC**. The command to enable this feature is “EPC=1” and the voltage input BNC connector on the Control Box is labeled “Analog Power Control”. This same input is available directly through the I/O connector on the back of the Stradus head (20 pin 3M 102 series). When enabled, the laser output power is directly proportional to the input voltage, with 5VDC equal to full output power for the laser type. When 0VDC is reached the output power always goes to zero, regardless of the laser type. The linearity of this input verses output power is well within 5%, however there is a 1% offset, such that in theory the zero output point will be reached at 0.05VDC on the input. This offset will appear as a non-linear response, as the output power is decreased to near zero, but is in reality an offset. The purpose of this offset is to assure that when 0VDC is connected to the EPC connector, the output power will be truly zero and not vary due to amplifier offsets or any other electrical errors.

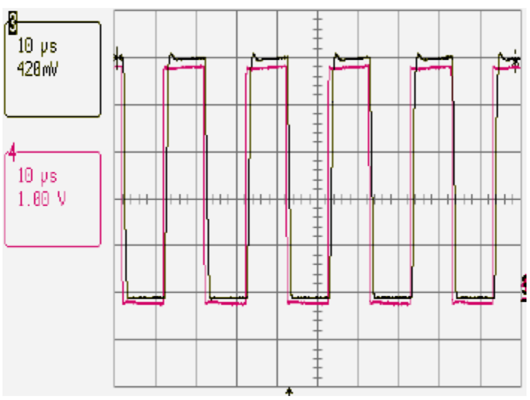
Below is an Oscilloscope photo of a 0-5V peak triangle wave on the EPC input and the resultant power output. This demonstrates the linearity available through this EPC input with EPC=1 and a 488nm Stradus laser.

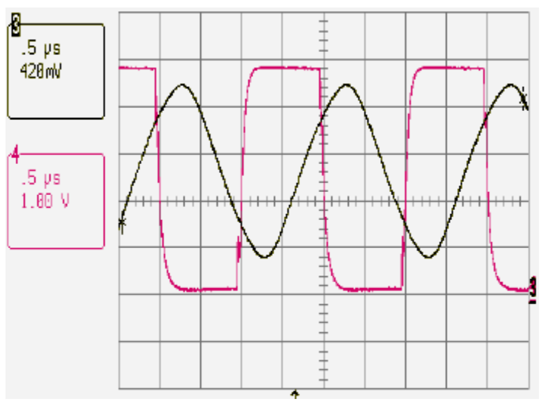


When the laser output power is set to less than full output power the EPC range is reduced. This is due to the fact that the EPC input is always set for 5VDC equal to full output power. Thus if the output power is set to 80% of full output power the voltage range of the EPC input would be 0 – 4VDC and the voltage between 4 – 5VDC would have no effect. The EPC control only decreases the output power it cannot be used to increase the power beyond the set power. The photo below demonstrates the decrease in EPC range as the set Stradus laser power is decreased to 80% of full power with a 0 – 5VDC EPC input with the same 488nm Stradus laser.

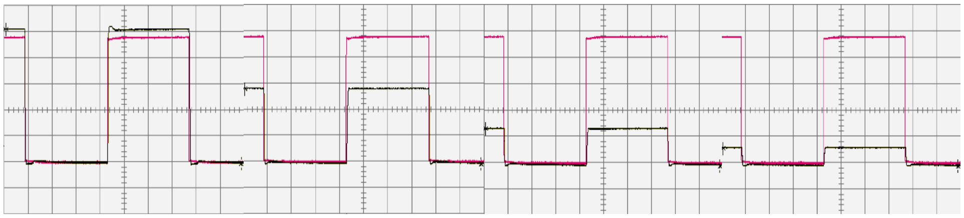


As stated above, the bandwidth of the EPC input is set by the light feedback control bandwidth. This is set to >500KHz, which will produce a rise and fall time of <0.7μs or 700ns, with the overshoot limited to <10%. This is a true single pole response, such that if the operator were to connect a 0-5VDC square wave to the EPC and increase the repartition rate to 500KHz, the output power waveform would contain only the fundamental frequency of 500KHz, as the higher frequency components of the square wave have been filtered to only a 500KHz sine wave. This is shown in the photo below, with a 10KHz square wave and a 500KHz square wave. It is important to understand that any frequencies above the bandwidth limit will not be accurately reproduced in the output power waveform.





One way that the EPC could be used is to independently vary the on-off ratio of the output and while being able to change the on power level using the computer control. When a 0 – 5VDC square wave is applied to the EPC, the output power is simply turned on and off at the rate set by the EPC input. Then the peak output power can be adjusted using the computer input. This process is demonstrated in the photos below.



The EPC input is protected by a series resistor and clamp diodes to limit the voltage to -0.3VDC and 5.3VDC. If the input is over-driven the clamp diodes take some time to reduce their effects on the waveform. This usually just introduces a delay and should be avoided. Also there is an internal pull up resistor working against a 1.2K load. If the EPC (EPC=1) is turned on with no connection, the EPC voltage will be 2.72VDC. This will reduce the output power proportionally and can be a cause of confusion if it is done unintentionally. The input impedance of the EPC is a fixed 660 ohms.

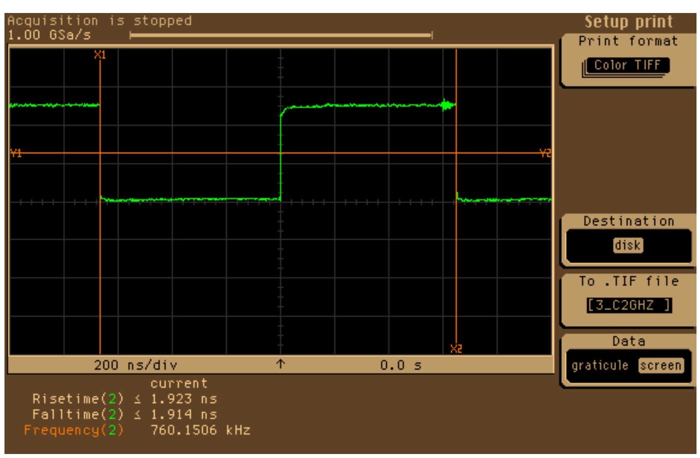
Digital Modulation:

The Stradus has a TTL input that produces on – off modulation of the output power. Stradus has an external SMB connector on the rear panel of the laser head for Digital Modulation. To enter the Digital Modulation mode the command is “PUL=1”. The input impedance is 50 ohms and it expects a TTL level signal. You should not use a high impedance signal generator source to drive the Digital Modulation input (SMB connector) as the 50 ohm input impedance will load the generator down and not allow the Digital Modulation to function properly.

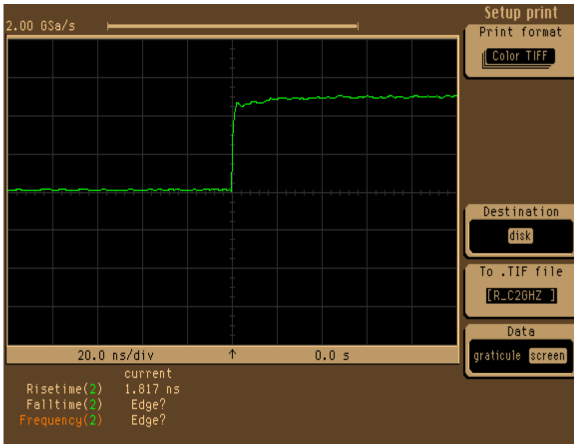
The principle difference between the Analog and Digital modulation is the power output with Analog modulation is proportional to the EPC input voltage while with the Digital modulation the output is simply on or off. The advantage of the Digital modulation is that it is much faster. Digital Modulation is able to turn the Laser on with a rise time of <2.0ns. This is dramatically faster than the EPC and is due to the mode of operating the Laser Diode. In the non Pulse Power (“PUL=0”) operating mode the power output is set by the light feedback control but when the Digital Modulation (“PUL=1”) is used the Laser Diode output power is controlled by a constant current source set by the internal microprocessor.

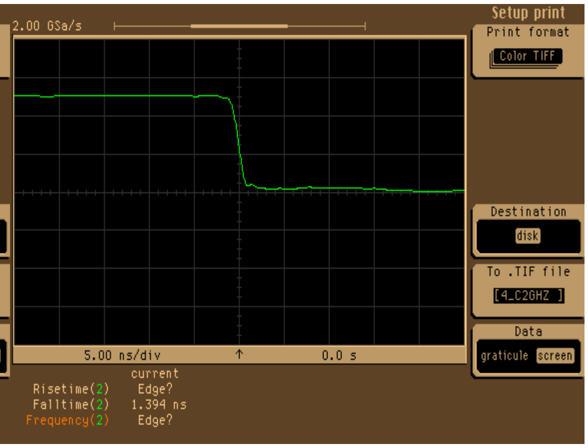
When operating in Pulse Power mode, the peak output power is adjusted by the microprocessor. The peak power in Digital Modulation mode can be set with the (PP=) command. The range of available values is determined by the maximum power for the laser being used. In the long term (weekly), it is necessary to periodically issue this command, as the Laser Diode will age and the power output will change for a given operating current. In the non Pulse Power mode the light feedback control compensates for this, but in Pulse Power mode a manual adjustment is necessary. PP and LPS are stored as two different values and will produce two different output power values when switching Pulse Power on or off (“PUL=1” or “PUL=0”).

The photo below demonstrates the Digital modulation with a 750KHz square wave from a pulse generator that has a <1ns rise and fall time.

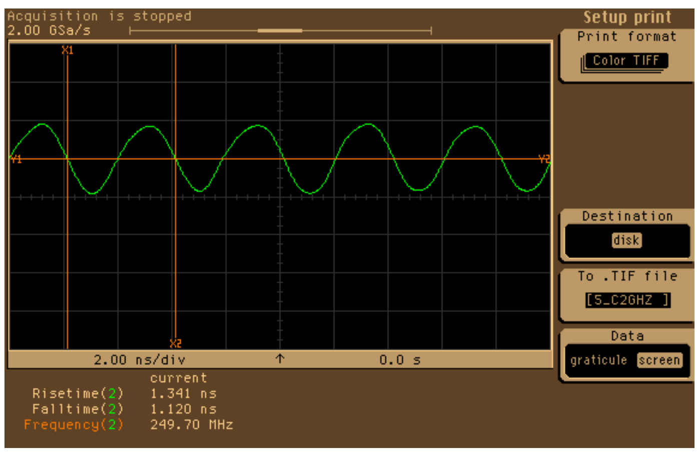


The next series of photos demonstrates the rise and fall times of the power output. Note: they may be different, as there is no active control of this (as you have with the light feedback control).





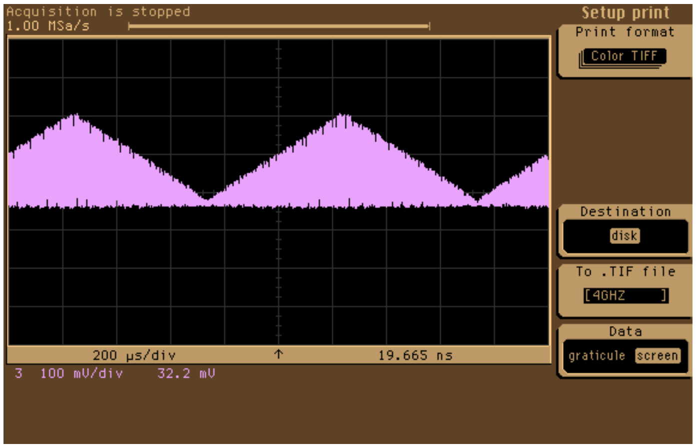
The next photo shows the power output with an input square wave of 250MHz. Note: That slight decrease in amplitude indicating we are close to the -3db (P-P voltage X .707) point.



Digital Modulation with EPC:

It is possible to combine the Digital modulation with the EPC function. The EPC function as we have seen above is External Power Control and it can be used with the Pulse Power operating, but it does have limitations. Because the Pulse Power mode uses a constant current drive for controlling the Laser Diode all we can do with the EPC in Pulse mode is to very the peak laser drive current. Again the EPC only drives the Laser current down and cannot be used to increase laser current and the other reality is that laser diodes have a characteristic know as a threshold current. This means that below the threshold current the Laser will not lase and produce light. The EPC in Pulse Power mode makes full current available when the EPC voltage is 5V and zero current when the EPC voltage is 0. So by definition it will not be linear as it was in non Pulse Power mode but we can get a modulation of the peak power value by varying the EPC voltage. Typically the range of 2.5V to 5.0V, will provide control of the peak output power. This is dependent upon the characteristics of the Laser diode and some experimentation may be necessary to use this function.

Stradus with the EPC input adjusted to provide full adjustment of the peak power when pulsed at a high rate.



Conclusion:

Stradus provides two ways to modulate the power output. Each has their own advantages and limits. We strive to provide as much versatility as possible, with the analog modulation (EPC) allowing a linear change in output power verses input voltage. To the digital modulation (Pulse Power) which has very fast rise and fall times. This combination allows wideband control of the power output using the Pulse Power mode and fine control with the EPC function. These functions may be combined to have analog control of the pulse power output.