Paralleling Laser Diode Drivers

PURPOSE

The laser diode industry has seen the output powers of laser diodes increase from milliwatts up to tens of watts and beyond. This increase comes with a similar increase in the drive current required to produce such output. As an example, five watts of fiber-coupled, pump laser light may require six to eight amps of drive current. Generally a laser diode lab will have several different current sources of varying output levels but most will not have sources capable of driving these higher power lasers. The quickest and most cost-effective way to run these lasers is by connecting two or more laser diode current sources in parallel to produce the necessary drive current. Depending on the operational mode, different connections between the laser and current source may be needed. This Tech Note describes the details involved in paralleling multiple current sources to run in both constant current and constant power modes.

CONSTANT CURRENT MODE

The simplest operational mode to run is constant current mode. One simply connects the positive current outputs from each source to the laser anode and the returns to the laser cathode. The appropriate current setpoints can then be entered. Once this has been done, the outputs may be enabled and fine-tuned if necessary. When using multiple sources in parallel, it is advisable to use enough sources so that they are not being run at their maximum output. This allows for compensation of future drops in laser efficiency. Connect the outputs of all current sources as close as possible to the leads of the laser diode. If the current sources have voltage sense capability, the sense wires should all be connected as close as possible to the laser leads as well.

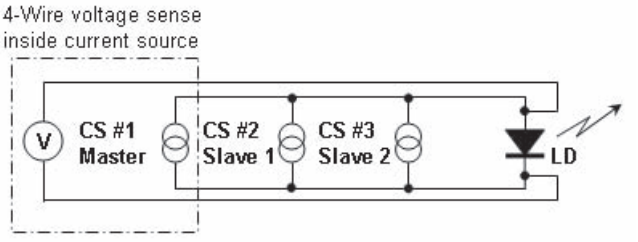

Figure 1 - Constant Current Mode

Figure 1 schematically shows the paralleling of three current sources to a single laser diode for operation in constant current mode. In this figure, there are separate connections shown for the current being delivered and forward voltage being measured. This is beneficial in ensuring an accurate voltage measurement by preventing the measurement of voltage drop in the cable caused by the laser current. The figure explicitly shows a single voltage connection to the master current source. While all current sources may have voltage measurement capabilities, only one measurement is required and measuring with the master is the most logical choice. The figure also makes reference to a master and slave arrangement for the current sources. In this case, the master current source would be adjusted if small corrections to the current are needed. The slave settings would only be changed if coarse adjustments were required. The distinction between which current source is master and slave is completely arbitrary in this case. This will not be true when running in constant power mode.

ILX Lightwave laser current sources have been designed with several protection circuits to prevent damage to laser diodes connected to them. One such circuit shorts the anode and cathode pins through a relay when the output is disabled. If several ILX current sources are connected in parallel and a single source is enabled, the current will be shunted through the shorting relays of the other sources instead of the laser. If the current setpoint is more than several milliamps, the output may be automatically disabled due to diode protection circuitry inside the current source. This protection circuitry will disable the output if it senses a very small voltage drop as would be the case during a short. However, this circuitry will not engage if the current setpoint is very small as well. Setting the output of the first source to 1 mA allows a safe amount of current to flow without engaging any protection circuitry. Once the first source has been enabled, all subsequent current sources may be enabled with an output of 1 mA as well.

If the current limits have not yet been set, they should be set to appropriate levels so that when all current sources are enabled, the combination of currents will not exceed the device's absolute maximum current. After a couple of seconds to let the current of each source stabilize, the slave sources may be ramped up to their required setpoints. Next, final adjustments can be made by ramping the master source up to reach the required laser operating point.

CONSTANT POWER MODE

Constant power mode is slightly more difficult to configure due to the required external feedback loop. This mode relies on the concept of master and slave current sources for it to work properly. The master current source is to be operated in constant power mode to provide small corrections to the laser current while all slave units are to be operated in constant current mode to provide the bulk of the power.

Paralleling Laser Diode Drivers *continued*

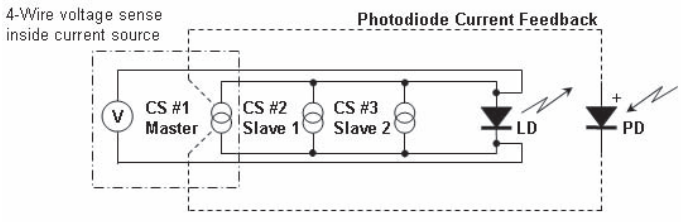

Figure 2 - Constant Power Mode

Figure 2 shows the connections required for constant power mode. The laser current and voltage connections are the same as when running in constant current mode. However, an additional connection (shown with dashed lines) is required between a photodiode and the master current source. The photodiode may be a backfacet monitor within the laser package, or it may be an external photodiode looking at a sample of the output reflected off a beam pickoff. The photocurrent output must be connected to the photodiode input of the master current source. Because the power sensor is a photodiode, positive current will be output from the anode side of the detector.

Once the photodiode connections have been made, a detector responsivity value at the appropriate wavelength must be entered into the master current source allowing setpoints to be entered in terms of optical power. If the responsivity value is not known, a constant photodiode current setpoint may be entered. The setpoint will be in terms of photocurrent, either milliamps or microamps, depending on the instrument and detector configuration. A maximum power limit may be set if the responsivity value is known so a second level of laser protection may be put in place. Again, the current limits of all current sources should be set to levels such that when maximum current is enabled, it will not exceed the laser's absolute maximum current.

The startup procedure for paralleled current sources in constant power mode is complicated by the photocurrent feedback loop. In this output mode, the master current source should always be in control of the laser current. This means that the master should be the first current source to be enabled and the last to be disabled.

The startup procedure is detailed as follows:

1. Enable the master current source. Since it cannot supply enough current to reach the required output setpoint, its output will be in current limit.
2. Enable the output of the first (if there are several) slave current source(s) set to minimal output.
3. Increase the current of the first slave current source until it is current limited or increasing the current has no further effect on the laser output, meaning the master is now regulating the current.
4. Enable the output on the next slave current source if there is one and increase its output until the master is in control of the output. Continue with any additional current sources that are required to bring the output into regulation.

Once constant power operation has been achieved, it is advisable to fine-tune the slave(s) to permit the master to operate near the top of its current range. Doing so will help minimize the chance of a current spike damaging the laser. Fine tuning of any of the current, power, or photocurrent setpoints, along with the responsivity value, can now occur. Disabling the output should occur in the order opposite that which enabled it. In other words, disable all slave current sources before disabling the master current source.

CONCLUSION

In summary, technology has advanced where laser diodes can now produce tens of watts of optical output or even more. This higher output necessitates higher and higher drive currents. People working with these types of lasers do not necessarily need brand new current sources to drive their higher power lasers. They can connect several current sources they most likely have in their lab together in parallel to produce the current required. Paralleling current sources can be operated in constant current mode or constant power mode. Constant current mode is by far the simplest mode to use because no external feedback loop is required to maintain the current level. The output of each current source can be set to add up to the required level to operate the laser diode.

Constant power mode is somewhat more challenging to configure because an external feedback loop involving the output from a photodiode is required. This mode requires all slave current sources to operate in constant current mode while the master current source is configured to operate in constant power mode. The slave sources provide the bulk of the current while the master provides the fine corrections necessary to maintain a constant optical power output.