Optimizing Laser Diode Control

INTRODUCTION

Laser diodes are used in a variety of applications, each utilizing the unique properties of semiconductor lasers. Creating effective systems can be complicated, but well worth the effort of optimization. Laser diodes are used in wide-ranging fields such as space research, spectroscopy, telecom laser manufacturing, medical lasers (surgery and diagnostics), gas measurements, LiDAR (Light Detection and Ranging), optofluidics, microfluidics, metrology, life sciences, and many more.

Laser diodes are compact and reliable. Extremely low noise and stable output wavelength can be achieved with laser diodes using the proper techniques and design. Laser system integrators must have a good understanding of the application and how the laser diode and laser driver fit into the system. Optimized diode control will reduce wavelength instability, noise produced and added to the system, and keep the user safe to operate the equipment.

This application note will provide a practical step-by-step guide to optimizing laser diode control with rule of thumb approximations that work with most laser diodes. This will show the recommended operating techniques of laser diodes with laser diode drivers for the optimum results.

As always, some laser diodes may be different and require special considerations. We have included a basic troubleshooting guide that covers the majority of problems our customers have encountered over time.

SYSTEM COMPONENTS

In a typical laser diode system, a driver (current source) is used to control the current from the power supply to the laser. **Figure 1** shows the basic layout of a laser driver system. The driver uses a feedback system from the laser or photodiode to correctly and accurately operate the laser. Application Note *AN-LD13: Laser Diode Driver Basics* goes into further detail about laser diode drivers. In the following sections, different aspects of the laser driver will be reviewed in detail for high performance operation.

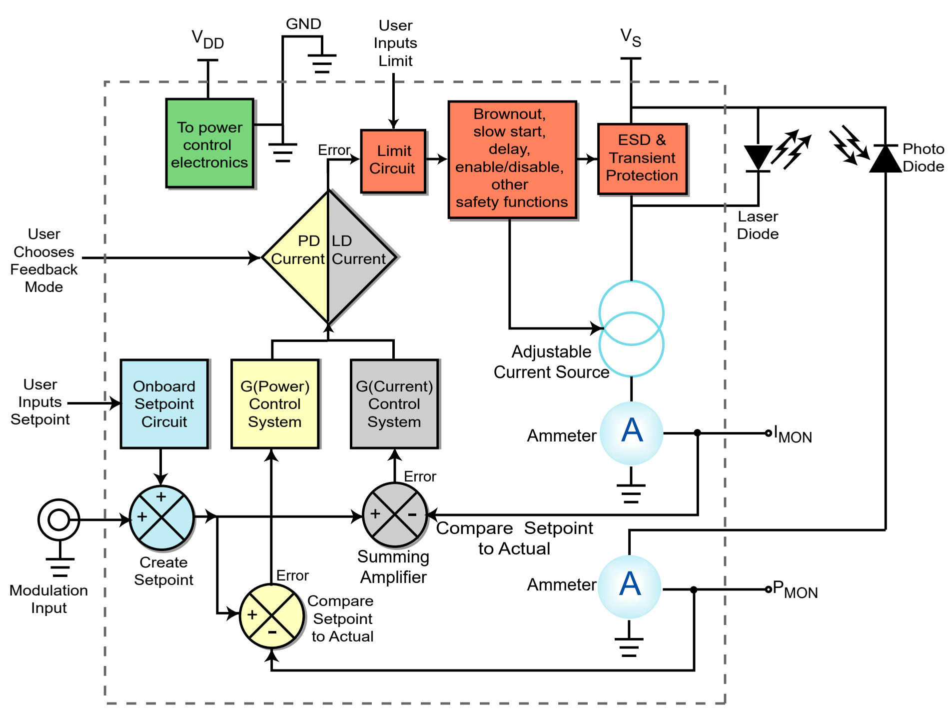

Figure 1. Laser Diode Driver Block Diagram

TEMPERATURE CONTROL

Although laser diode drivers are important to operating a laser diode, temperature control is also vital to correctly and safely using a laser diode. The output of a laser diode, like other electronics, is affected by its ambient temperature. In the case of laser diodes, a change in temperature can shift the wavelength of the output of the laser. This can occur when there is an increase in injection current or a change of ambient temperature (**Figure 2**).

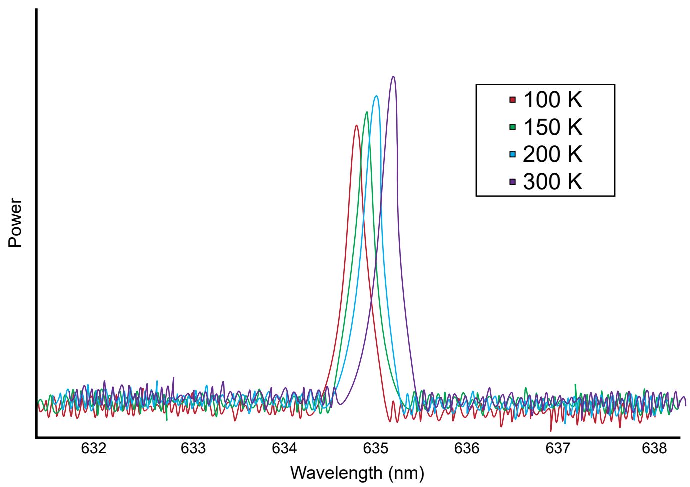

Figure 2. Intensity vs. Wavelength with Multiple Temperatures

The wavelength shift may not be large, but it could affect delicate laser setups. The change in temperature will affect the bandgap energy, the refractive index of the laser diode, and therefore the peak wavelength. When there is an increase in temperature, output power will decrease and the threshold current of the laser diode will increase. Like most electronics, laser diodes are not 100% efficient with the supplied power. There will be heat dissipation within the laser, changing the characteristics of the output. Controlling the temperature of the laser will control the output. Commercial temperature controllers have the ability to control the temperature using Thermoelectric Coolers (TECs) to as low as 0.0009ºC precision. The coolers will help to control the ambient temperature around the laser as well as the internal temperature of the laser due to the input current.

The output power of the laser can also be affected by the temperature of the laser. **Figure 3** shows a plot of output power of a laser diode versus input current. The threshold current (current at which stimulated emission and coherent light is produced) increases as temperature increases, and the output current decreases with a fixed input current. As the temperature cools, the threshold current decreases. This is why many experiments maintain lasers at cooler temperatures, increasing the efficiency. Refer to the laser diode's datasheet for recommended operating temperature range.

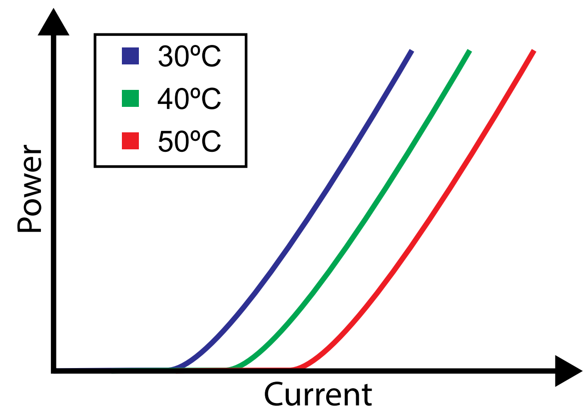

Figure 3. Output Power vs. Input Current with Multiple Temperatures

Laser diode drivers can also have their output current affected by temperature. Most datasheets will list a temperature coefficient for the driver in ppm/ºC (parts per million per degree Celsius). As temperature changes, the output current of the driver will slightly shift. Typical values range from 25 to 300 ppm/ºC, but these are still relatively small changes compared to the total output of the system. For example, a laser driver with output current of 1.5 A and temperature coefficient of 300 ppm/ºC will produce a shift of 0.045 A for a 100ºC temperature change.

Technical Note *TN-TC01: Optimizing Thermoelectric Temperature Control Systems* shows practical temperature control techniques using temperature controllers and TECs.

FEEDBACK MODE SELECTION

Most laser diode drivers will allow control based on laser current or photodiode current feedback. These are labeled as Constant Current (CC) and Constant Power (CP), respectively. This will allow the driver to maintain the specified output as constant as possible. **Figure 1** shows the basic layout of both feedback systems (yellow and gray feedback modes).

CC mode will use the current through the laser diode as feedback into the system. If the current is not constant, an error will be produced in the design circuity to drive the current back to the setpoint.

CP mode will use the current through the photodiode as feedback into the system. The photodiode monitors a fixed portion of the light generated by the laser diode. The photodiode manufacturer can provide a rough transfer function relating the photodiode current to the laser diode power output (mA/mW or µA/mW). The photodiode current is linearly related to the optical power of the laser diode. The driver will adjust the current to the laser diode to keep the optical power level constant.

CHOOSING CONSTANT CURRENT OR CONSTANT POWER MODE

In some cases, constant wavelength is critical, but having a wavelength meter provide feedback is not practical. The laser can be driven in constant current mode to keep the current through the laser constant as well as the wavelength. Because temperature is also critical to stabilize wavelength, it can be scanned to achieve the desired wavelength, then held constant.

In other cases, constant power is required. One example is sensing applications to illuminate a sample measuring absorption, reflection, or scattering. Here the detector senses power, so a constant input power is necessary to maintain calibrated measurements. Another application requiring constant power is communications when signal degradation affects signal to noise ratio and system performance. To insure constant power output, feedback from the integrated photodiode is monitored and the laser diode current source increases its output until it reaches a preset current limit. This is important as laser diodes lose power as they age - more current is required to achieve the same power over time.

NOISE

Noise can become an issue when making high precision or near noise floor measurements. This is unwanted signal or fluctuation in the signal. There are various sources of noise including: cables, laser driver, system connections, power supplies, external electromagnetic interference, and the selection of the photodiode. Noise is usually denoted in micro-amps (µA). Spectral noise density (nA/√Hz) can also be measured and shows the performance at specific frequencies across a measurement bandwidth. Accumulated root-mean-square (RMS) noise can be determined from the spectral noise density measurement over any arbitrary bandwidth within the initial measurement bandwidth and shows the overall noise over a frequency range. Application Note *AN-LD09: Troubleshooting Low Noise Systems* can help improve and reduce the noise level of the laser systems with simple techniques.

Wavelength Electronics uses a high quality spectrum analyzer and a pre-amplifier to measure the noise from laser drivers. When using a spectrum analyzer to test noise levels, first check the noise floor to confirm it is lower than 50 nV/√Hz. The noise floor at Wavelength is ~15 nV/√Hz at 1 kHz. A pre-amplifier should be used to bring the device under test's (DUT) noise to an amplitude well above the noise floor of the system. A battery powered pre-amplifier should be chosen to keep noise at a minimum. The system will back out the pre-amplifier gain and measure the noise of the device. The noise density of the system at Wavelength is ~4 nV/√Hz. It will be common to see a spike around the 60 Hz power line noise.

Not all noise can be eliminated or reduced. The physical properties of materials or the laser diodes themselves will produce a minimum amount of noise. The lowest level of noise in resistors is called Johnson voltage noise density. Johnson noise of a resistor can be calculated using:

$$\sqrt{4k_BTR}$$

where k_B = 1.38 x 10^{-23} (Boltzmann's constant), T is temperature in Kelvin, and R is resistance in ohms. Below is an example using a 10 kΩ resistor at 300K. Total noise is added in quadrature. $Noise_1$ is the noise calculated of the resistor. $Noise_2$ is the pre-amplifier noise of 4 nV/√Hz.

$$\sqrt{4*(1.38x10^{-23})*300*10^{-4}}$$
$$= 12.9 \text{ nV}/\sqrt{\text{Hz}}$$
$$Noise_{Total} = \sqrt{(Noise_1)^2 + (Noise_2)^2}$$
$$Noise_{Total} = \sqrt{(12.9x10^{-9})^2 + (4x10^{-9})^2}$$
$$= 13.5 \text{ nV}/\sqrt{\text{Hz}}$$

Current noise density (nA/√Hz) can be calculated from the voltage noise density and the resistance of the load.

$$\frac{\text{Voltage Noise Density}}{\text{Resistance}} = \text{Current Noise Density}$$

where the units are:

$$\frac{nV/\sqrt{Hz}}{\Omega} = nA/\sqrt{Hz}$$

Using shorter wires and twisting the wires (**Figure 4**) can significantly reduce the noise conducted into the connections. Twisting the wires will reduce the effects of magnetic interference and ultimately reduce noise. Cross-talk between the conductors can also be eliminated.

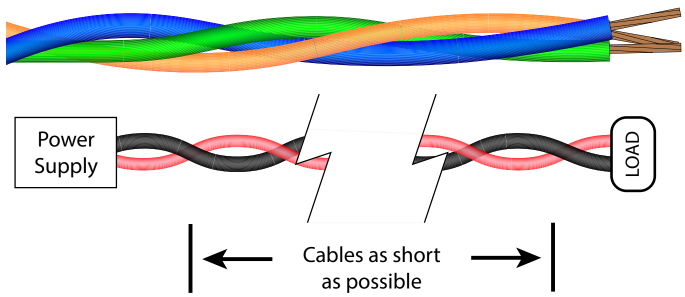

Figure 4. Twisted wires (top) and short, twisted wires from a supply to the load (bottom)

Shielding wires and cables is an effective method to reduce the noise created from interference. Braid and foil shielding are the most common methods of shielding against interference. Application note *AN-LDTC09: Cabling Basics* has more information on cabling techniques.

Many problems can be created with wires and cables in the design of the system. Conductors can pick up small amounts of Electromagnetic Interference (EMI) that can significantly reduce the signal-to-noise ratio. EMI can come from power supplies and other electronics. Cables or wires can pick up interference alongside the original signal between the components, or they can reflect it away from the conductor. The length of the connections and the shielding have critical impact on the noise conducted through the system. Longer leads will result in a larger voltage drop, wire heating and decreased modulation bandwidth. **Figure 5** shows the effects of longer wires (> 2 feet) with AC interference from an electrical outlet in a spectral noise density measurement. It also shows the effects of shorter wires with minimal AC interference by using a battery. The noise is significantly reduced while lowering the overall spectral current density level. **Figure 6** shows the RMS version of the cumulative noise level for the driver with short cables and minimal AC interference.

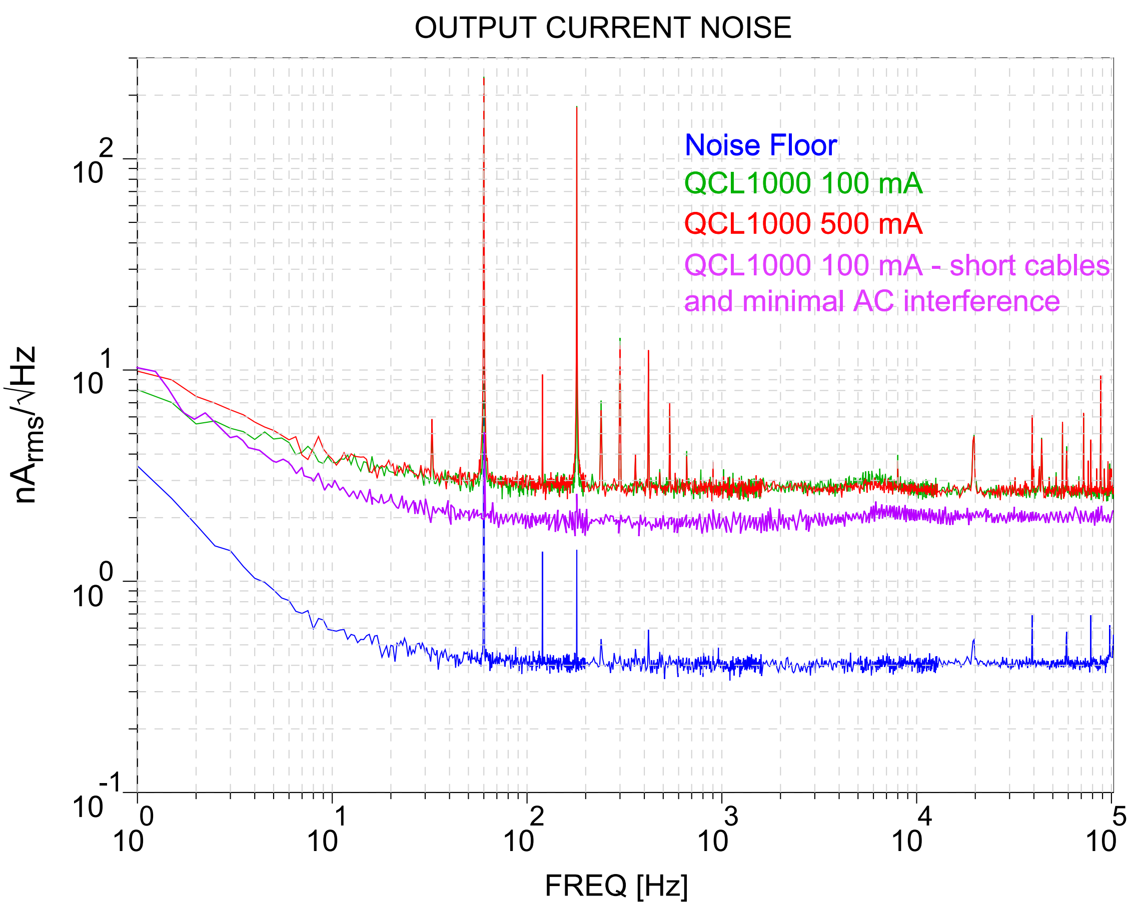

Figure 5. Example Spectral Noise Density with long cable, AC interference, various current levels. The purple line shows an example spectral noise density with shorter cables (< 2 feet) and minimal AC interference.

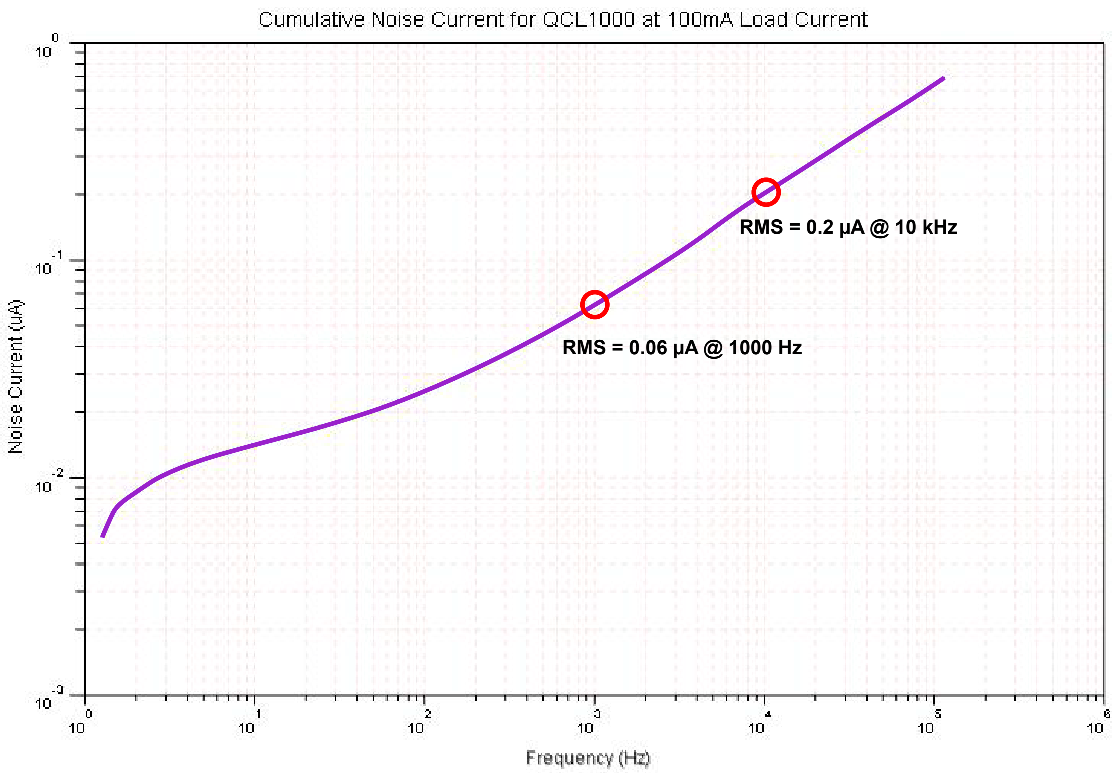

Figure 6. RMS noise - Integration of data from Figure 5 QCL1000 with shorter cable and minimal AC interference

Certain photodiodes can also add to the noise levels. It is not always possible to choose the photodiode, but the mode of operation can reduce noise. Avalanche photodiodes create the most noise, and PIN photodiodes produce the lowest noise. Other parameters, such as photodiode speed and cost, should also be considered for the system layout. Using an unbiased photodiode (photovoltaic mode) will generate lower noise compared to reverse biasing the photodiode (photoconductive). The breakdown voltage is a maximum voltage for reverse biasing the photodiode. Pushing this limit will damage the photodiode. **Table 1** compares photodiode types with different parameters. More information on photodiodes can be found in the *Photodiode Basics* page.

Table 1. Photodiode Comparison Chart

	PHOTODIODE TYPE		
PARAMETER	**P-N**	**PIN**	**APD**
PHOTO-VOLTAIC	Best	Good	Poor
REVERSE BIASED	Good	Best	Good
LOW LIGHT	Poor	Good	Best
COST	Best	Good	Poor
LOW NOISE	Good	Best	Poor

Laser drivers can contribute a sizable portion of noise into the laser system. For high performance and low current measurements, noise levels should be close to a single nA of noise. The best commercial laser drivers will deliver even lower noise (<1 nA) for critical measurements. Some applications and systems, however, do not require such low noise specifications.

PACKAGING & GROUNDING

Laser diodes can come in a variety of forms. Each diode packaging type serves a different purpose with different benefits or drawbacks regarding heatsinking, laser output, size, cost, and setup. The majority of laser diodes are manufactured in the following packages: TO-can, butterfly, c-mount, and diode bar. Some packages will incorporate a fiber coupling to direct the laser beam, while others will emit the laser beam into a free-space optic setup.

The TO-can (**Figure 7**) is a cylindrical package and comes in a few sizes: 3.8mm, 5.6mm, and 9mm are the most common. This package includes some heatsinking and a distinguishable cap over the perpendicular (to base of the package) emitting laser. A photodiode is included in the package, making the TO-can one of the most compact and least expensive designs.

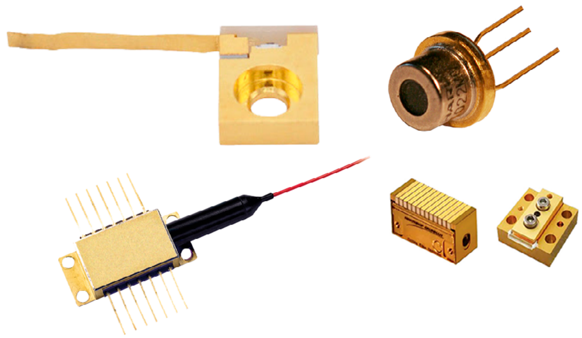

Figure 7. Common Laser Diode Packages: C-Mount (top left), TO-can (top right), butterfly (bottom left), and diode bars (bottom right).

The butterfly mount (**Figure 7**) is slightly larger than a TO-can, but it has a few benefits to counter the drawbacks. Most butterfly 14-Pin packages come with an integrated TEC as well as a mounting plate to dissipate more heat. The 14-Pin layout allows for custom designs with great flexibility. Butterfly laser diode mounts are sold to operate the diode with current control and temperature stability and heatsinking capabilities. They also are easier to fiber couple.

Another type of laser diode packaging is C-mount (**Figure 7**). In this package, the laser diode chip is exposed rather than protected or covered, but the laser has a high output power. This allows other components in the design to be right up against the front facet of the laser. The base is a good heatsink for the laser while providing screw mounting. Common C-mounts have one lead protruding from the top of the heatsink block. The cost of this package is relatively low.

The last commonly used package is the diode-bar (**Figure 7**). This is a two-dimensional array of emitters which allows much higher combined power than a single laser diode emitter. With this high power output comes a spatial pattern of the beam that is not highly desired, but external components can compensate for this. Diode-bars can be stacked together to create “diode-stacks” and generate very high output power.

Regardless of what laser type is used, careful attention needs to be given to how the laser and the system are grounded. Grounding may seem like a simple task, but it is easy to create ground loops and damage expensive components in the process.

Packages may come with the laser diode anode or cathode grounded. Some design cases may allow for the laser diode to be electrically isolated from earth ground. If the laser is in a remote location in the system, the anode or cathode may not need to be grounded. If the laser will come in contact with human touch, the anode or cathode will need to be grounded to protect from static discharge or protect the patient in a medical application. This also ensures that the user will be protected from the laser system. Application Note *AN-LD16: Grounding with Special Laser Diode Configurations* has further details on grounding schematics.

Most laser diodes will need heatsinking. For very low power operation, a baseplate with natural convection is generally sufficient. Increasing power will require a heatsink, heatsink with forced air, or active cooling. Laser diode and laser diode driver datasheets will list at what power levels heatsinking is required. The Safe Operating Area (SOA) is used to determine how much power will be internally dissipated in a product under varied operating conditions. For easy calculation using Wavelength Electronics’ drivers or controllers, use the SOA Calculator. Active cooling implies water cooling or thermoelectric coolers. The size of the heatsink needs to have sufficient surface area for adequate heat dissipation. It should be noted that thermoelectrics are poor in efficiency - 10 to 15% efficiency is common. Thermal contact between the load and the heatsink or thermoelectric cooler is critical to the efficiency of the temperature stabilization and heat dissipation. Technical Note *TN-TC01: Optimizing Thermoelectric Temperature Control Systems* provides a practical guide to themoelectric cooler system design.

LASER DIODE TYPES

Unfortunately, there is no standardization in the laser diode industry for laser diode pin layouts. In the laser diode datasheet, connections should be clearly defined as well as shown in drawings or schematics.

Laser diode driver manufacturers will list which laser types can be used with specific drivers. There is a different system for distinguishing laser types in butterfly packages. This is the most standardized of laser diode packaging. **Figure 8** and **Figure 9** show Wavelength’s Standard Type 1 Butterfly package and the Standard Type 2 Butterfly package respectively. There are other varieties of butterfly packages, but Type 1 and Type 2 are the most common.

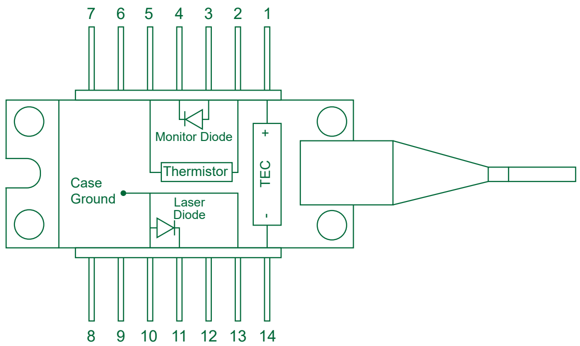

Figure 8. Standard Type 1 Laser Diode Butterfly Schematic

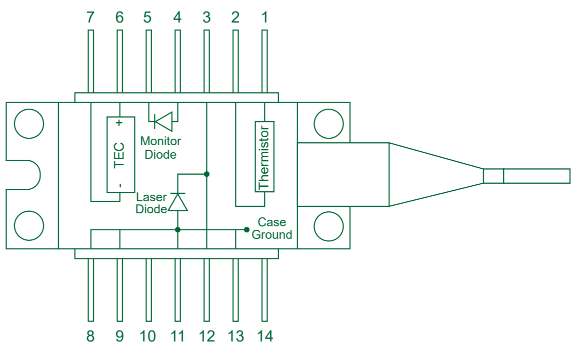

Figure 9. Standard Type 2 Laser Diode Butterfly Schematic

Figure 10 shows Wavelength Electronics' laser types A, B, and C. Because there are many different configurations for different manufacturers, Wavelength has developed this standard for laser diode control that includes the majority of laser diodes and easy to understand diagrams. These descriptions will indicate how the laser and the photodiode are connected or not connected (Type B laser diode shows the photodiode isolated from the laser diode). Butterfly-packaged laser diode mount datasheets include diagrams for the laser, photodiode, and TEC wirings. Always check the laser diode datasheet and the laser driver datasheet for laser type confirmation before operating the laser.

The laser driver datasheets at https://www.teamwavelength.com/product-category/laser-diode-drivers/ will list the supported laser types on the front page of the datasheet as well as the webpage for the laser driver. The laser type icons are shown below in **Figure 11**.

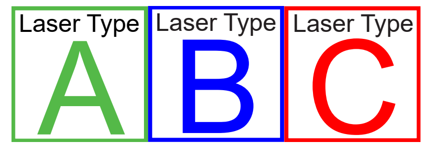

Figure 11. Laser Type Icons

MODULATION & PULSING

It is a common mistake to confuse modulation with pulsing. A pulsed laser releases large bursts of energy periodically as seen in **Figure 12**. This is usually a much higher peak power than continuous wave (CW) and a much higher frequency. Pulses can have durations as short as femtosecond, but CW modulation pulses can only reach microsecond durations. A pulsed laser can have, for example, an average power of only a few μW but a peak power of a few hundred mW. This is due to the low duty cycle (fraction of the time the laser is turned on per period) because of the short laser pulses compared to the time no pulsed is emitted. A laser that is modulated is simply turning on and off periodically at a much lower frequency (**Figure 12**). The average power of a modulated laser will be the peak power multiplied by the duty cycle. A max power is set, and the frequency of the on and off does not change the max power. Rise time, fall time, and overshoot are all important factors when modulating the laser.

Some applications will just require a laser diode running in CW mode, but others may require a pulsed laser diode or a modulated laser diode. Analog and digital input signals can be used to create modulated signals with specific pulse shapes at various on and off states.

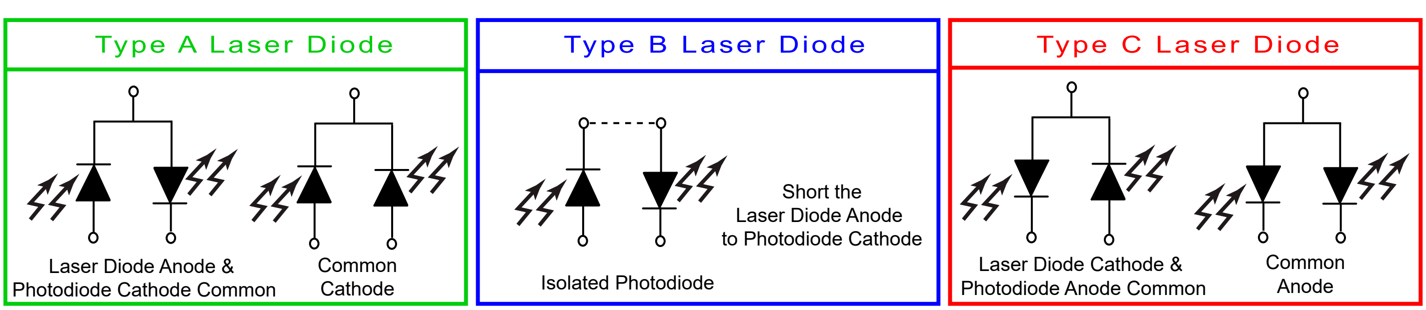

Figure 10. Laser Diode Type Diagrams

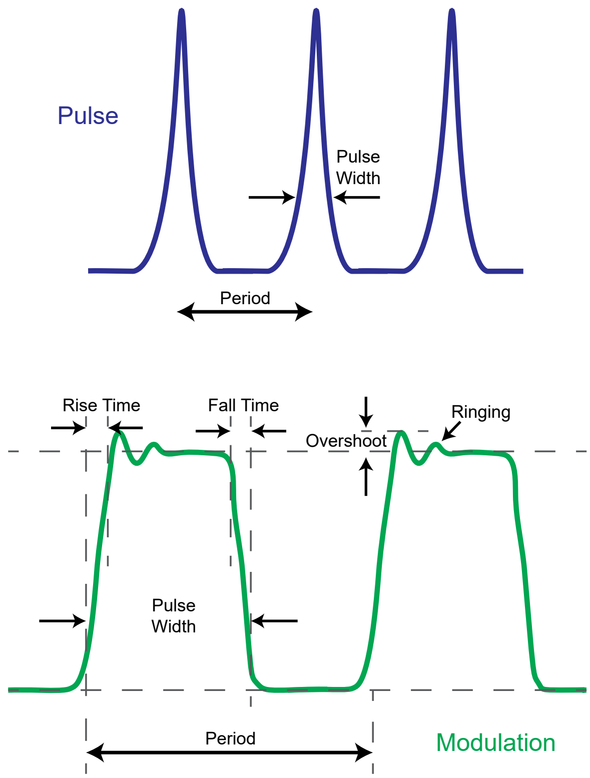

Figure 12. Pulsed (top) and Modulated (bottom) laser beam output power

Rise times and fall times will never be instantaneous. The rise time is how quickly the signal changes from 10% of maximum to 90% of maximum, and the fall time is the opposite. This can be seen in **Figure 12** which shows a typical output for a square wave modulation input.

Generally, higher frequency modulations will cause a large amount of ringing during the "on" phase. This can cause problems if the current limit is close to the higher portions of the ringing, or the current setpoint can be exceeded damaging the laser.

CW Circuits are often given a bandwidth specification. This indicates that the circuit will not pass all frequencies in a time varying setpoint signal. If the bandwidth is exceeded, sine waves will be attenuated and square waves will lose the square edges. Fast rise and fall times are needs for generating the sharpest corners, and they limit how fast a driver can deliver changing current to the load. Application Note *AN-LDTC05: Bandwidth Basics* has more information.

Modulation can also be affected by negative bias, long wires, unfiltered signals, and untwisted wires from the power supply. Not only can these issues cause noise, as described earlier, they can deform or distort the current output from the driver to the laser when modulating the signal. The following scenarios use a 20 kHz square wave modulation through a laser diode driver.

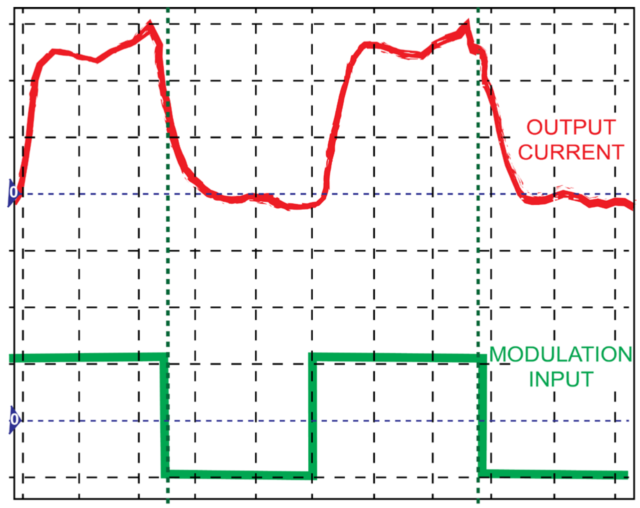

Figure 13. 20 kHz Square Wave, Negative Bias

The first issue arises if the square wave signal has a negative bias. **Figure 13** shows the distortion negative bias creates to the square wave. To correct it, adjust the bias to be at ground or a positive bias of about 20 mV. Remember each system is different and the bias level is dependent on the system noise.

At higher currents, (anything above 5 A), the power supply wire length plays a major role in whether the design will succeed. It is recommended to use a maximum of 2-feet, shielded, 14-16 AWG for the power supply cable. The cable needs to be twisted to reduce noise that is generated in a system.

Figure 14 and **Figure 15** show the effects wire length and configuration have on the modulation waveform.

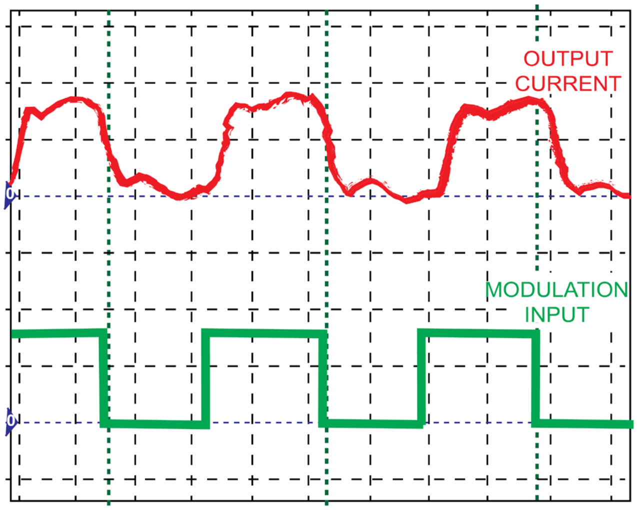

Figure 14. 20 kHz Square Wave, 4-foot twisted wires

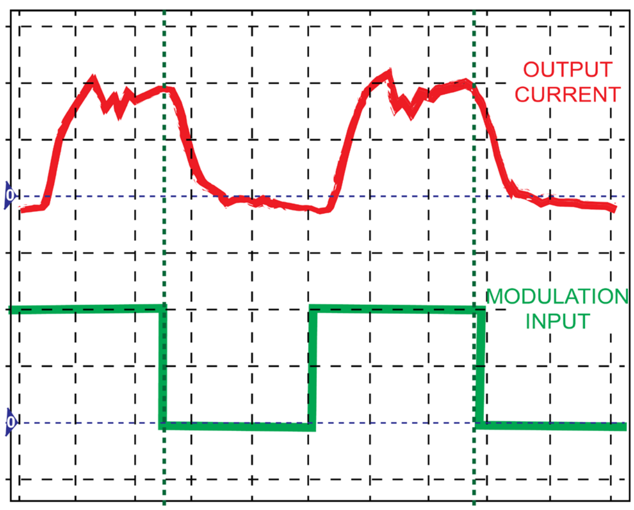

Figure 15. 20 kHz Square Wave, Unfiltered, Untwisted Wires

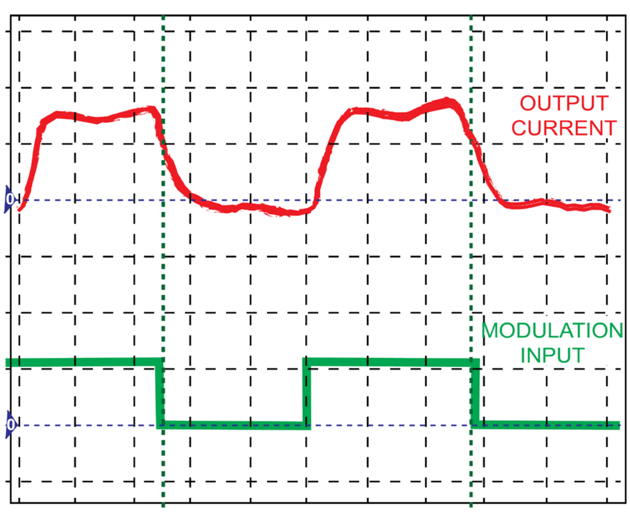

Figure 16. 20 kHz Square Wave, Filtered, Untwisted Wires

If longer wires cannot be avoided, filters can be implemented to reduce noise and fluctuations in the modulation. An example of filtering is using 4-foot twisted 14 AWG wires with a 470 µF filter capacitor at the power supply or driver side. An example filtered system can be seen in **Figure 16**.

POWER SUPPLY & DRIVER

Power supplies come in two forms: linear and switching. With either supply used, the load should be physically separated or shielded from the power supply to decrease noise as described earlier in the noise section.

A linear power supply utilizes a transformer and rectifiers to produce clean DC voltage from AC input. This supply has low noise output and is high performance. However, it is usually quite large, heavy, has low efficiency (heat dissipation issue), and is more expensive.

A switching power supply uses pulse width modulation to regulate output voltage. This supply has higher efficiency, is more compact, and is more budget friendly. However, this supply produces a significant amount of noise especially at the switching frequency.

If low current measurements are part of the design, a linear power supply is recommended for lower noise generation. If noise is not an issue, a switching power supply will be beneficial in smaller spaces for a lower price.

Compliance voltage is the power supply voltage minus the internal voltage drop across the laser driver. This is the maximum voltage that can be delivered to the laser. Laser drivers will list this value, based on the supply voltage value, in the datasheets. Different lasers will have a variety of voltage drops. Careful consideration needs to be taken when using one laser driver to drive multiple lasers. Multiple lasers in series (not parallel) can only operate with at least the combined voltage drops of the lasers. The current, for lasers in series, will be the same. Always refer to the datasheets or contact the laser driver manufacturer to confirm safe operation. Problems with compliance voltage are explained in the troubleshooting section.

SAFETY FEATURES

Laser diodes can be damaged with too much current. It is easy to destroy a laser with current overshoot. Power supplies are passive in regulated power and current to the diode. Current sources (or laser driver) limit and drive exactly the current specified by the user, significantly reducing risks of damage to the laser. Laser diode drivers have many safety features to protect the laser (some are government regulated):

- Current limit - This protects the laser from current overshoot. Some drivers will have a “brick-wall” circuitry to stop current from exceeding this limit.
- Time delay - This is the delay between application of electrical power and lasing.
- Interlock - This feature will shut off the laser if the housing or a door is opened, assuming correct wiring. This protects the user (and others) and the laser system.
- Slow start - This will protect the laser diode from thermal shock and gradually produce current until reaching the setpoint.
- Brownout protection - This will shut off the output when the voltage droops and threatens control integrity of the driver.
- Electro-static discharge (ESD) protection - This protects the laser diode against ESD shocks or transients from the power supply.

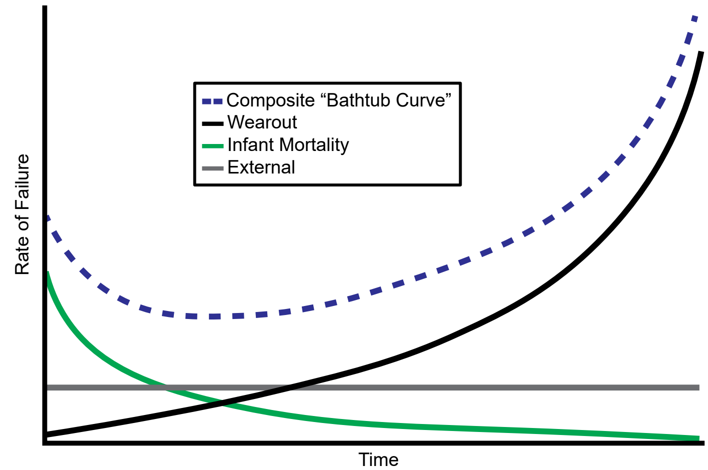

Figure 17. Laser Rate of Failure vs. Time

Laser diodes also should be carefully examined and researched before operation. Degradation of laser diodes can become an issue with performance and efficiency. Over the lifetime of the laser, the efficiency will decrease alongside the output power for a given current. It will take more power in to get the same power out. Operating temperature is one aspect that contributes to the aging process: Increasing temperature leads to increasing degradation speed. Moisture and current surges can also add to laser degradation, also known as wearout. Laser handling and heatsinking are other critical aspects to consider.

Alongside laser diode degradation over time, infant mortality and external problems can contribute to laser failure or hazardous operation. Infant mortality results from defects in manufacturing. These issues usually are quickly discovered when they are burned-in with high current and high temperature. As the diode is operated, the chances of infant mortality quickly decrease. Laser failure from external sources can come from drop damage, user mistake, or electro-static discharge damage. This is an on-going, constant hazard when operating laser diodes. **Figure 17** shows the chances of laser failure or damage with respect to time. A “bathtub” curve is added to show the trend of overall damage and failure risks throughout the laser’s lifetime.

Lasers are also classified for safety purposes for protecting users from harming themselves or others by the International Electrotechnical Commission (IEC) and the U.S. Food and Drug Administration (FDA). Lasers are divided into four main classes, Class 1 lasers being the lowest risk of injury and Class 4 being the highest risk. There are different standards based on eye damage from direct exposure or reflected laser beams and skin damage. Always check the laser diode datasheet for safety information and guidance.

WAVELENGTH’S SELECTION

Wavelength offers three types of laser diode drivers: components, modules, and instruments. These are high precision, patented low noise drivers enabling development or research.

Components (**Figure 18**) (up to 3 A) are small (usually 2.0” x 1.5”) and provide lower current. There are generally no moving parts, they connect to circuit boards via pins for mounting, and require a power supply and voltmeter to monitor the settings. Components are the most compact driver offered, and heatsinks and evaluation boards are available for rapid prototyping.

Figure 18. Component (top), Module (left), and Instrument (right). Size is not proportional between devices.

Modules are slightly larger (3.9” x 3.2” on average) and are more of a standalone unit. There are moving parts (trimpots, switches, or jumpers), but they only require a power supply and a voltmeter for measuring voltage/current. Modules can be mounted on benchtop or inside a chassis. Heatsinking may be required depending on the application and power dissipation. Cables, not pins, are used to connect to modules.

Instruments are designed for researchers that need flexibility and ease of use. They are the largest laser driver Wavelength offers (2U half rack in size) and come with fully functioning touch screen user interface. A power supply is built into the instrument and plugs into AC wall power. Instruments provide the greatest ease of use and versatility, while maintaining high performance.

When choosing what packaging of laser drivers works best in the particular application, output current and voltage, noise, size, whether the driver is being designed in, heat dissipation, and temperature control all need to be considered as well as the safety features previously discussed.

TROUBLESHOOTING

Because the rules given here are general rules of thumb, some tweaking may be necessary to account for special laser and driver circumstances. The following list details common problems, their definitions, and suggestions for solving them.

LASER OUTPUT POWER TOO LOW IN CC MODE

The light from the laser may not be coherent, stimulated emission, or not lasing.

1. The laser current setpoint may be too low. Increase the setpoint on the laser diode driver or with an external voltage setpoint without exceeding the damage threshold of the laser. The setpoint must be above the threshold current for the laser to operate properly.

2. The laser current limit may be too low. Increase the current limit on the laser diode driver or use the instructions in the appropriate datasheet. Ideally the current setpoint would not be too close to the current limit and operate “in-limit.” Do not exceed the damage threshold.

3. Laser driver may be compliance limited. Check the laser diode specifications to determine the forward voltage. Compare to the compliance voltage limit in the driver datasheet (Electrical Specifications table). If the driver is compliance limited, the voltage through the driver to the laser may need to be increased. **NOTE**: Verify that the driver will be operating withing the Safe Operating Area (SOA) if the voltage is increased.

LASER OUTPUT POWER TOO LOW IN CP MODE

This is similar to the previous problem, except the laser is operating in constant power mode.

1. The laser current may be too low. Check the laser diode datasheet to determine the approximate laser drive current at the desired optical power output level. Then verify that the current limit is set slightly higher than that. The driver datasheet will have instructions on setting the laser driver current limit. Do not exceed the damage threshold.

2. The photodiode feedback current may be out of range for the laser driver. Refer to the laser diode datasheet to determine the approximate photodiode current at the desired output power level. If the photodiode exceeds the laser driver current range, use a different photodiode or adjust the photodiode range on the laser driver if applicable.

LASER DRIVER WILL NOT SWITCH ON

1. The power supply(ies) may be configured improperly. Carefully check the wiring diagrams in the laser diode datasheet. Make sure the power supply polarity is not reversed.

2. The power supply voltage may be too low. Some laser drivers include brown-out protection circuitry that disables the laser driver if the power supply voltage falls below a certain level. Make sure the power supply voltage is correct.

LASER DRIVER OUTPUT WILL NOT ENABLE

1. The interlock or enable switch/signal may be improperly configured. Check the laser driver datasheet for proper orientation of switches or shorts that need to be made to enable output of the laser driver. WEI laser driver instruments will have both passive and active interlocks to protect the laser with immediate shutdown upon detecting a interlock error.

2. The laser driver needs power to operate. Connect a power supply to the laser driver to provide current to the laser.

OPTIMIZATION BEST PRACTICES

CONTROL TEMPERATURE

Determine the heat dissipation in the laser and the laser driver. If the heat dissipation is greater than the value allowed by the device without any temperature control, use a heatsink or a active cooling device such as a thermoelectric to properly dissipate the heat.

SELECT FEEDBACK MODE

Use Constant Current (CC) if your application requires a stable wavelength, and use Constant Power (CP) if it requires a constant output power. Most drivers will provide a simple way to set the feedback mode.

REDUCE NOISE

Calculate and measure the noise of the system. Twist wires from the power supply, shield conductors in cables, and filter any signal if traveling farther than two feet. Move the device away from the power supply.

SELECT PACKAGING & GROUNDING

Determine the system's size, power output, and cost limitations, and select the proper laser diode packaging type. Ensure no ground loops will be created in setup.

OPERATE WITH MODULATION (OPTIONAL)

When modulating the signal, avoid negative bias, untwisted and long wires without filters, and exceeding the specified bandwidth of the system.

SELECT POWER SUPPLY & DRIVER

Use a linear power supply for low current measurements or a switching power supply for measurements without noise concerns.

SAFELY OPERATE THE LASER

Read the laser diode and laser diode driver datasheets to find all the safety features listed to protect the laser and the user. If the laser is used for prolong periods of time, pay attention to the degradation of the laser and output power.

KEYWORDS
laser diode, laser diode driver, temperature controller, noise, constant current, constant power, packaging, grounding, power supply, laser diode safety features, temperature coefficient, shielding, heatsink, modulation, pulse, low frequency

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