



# Grounding with Special Laser Diode Configurations

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## INTRODUCTION TO GROUND

Grounding a laser diode and the associated driver electronics does not seem, at first glance, to be a difficult proposition. But the simplest things can cause the most trouble, and trouble in this case can be unexpected optical noise or a destroyed laser.

A proper grounding scheme is critical to successful implementation of a laser control system. But it's not so obvious just what constitutes a "proper" grounding scheme.

In this Application Note we'll explain a wide variety of best practices for grounding laser diodes and drivers. We'll point out common dangers and ways to avoid them, and help you to build robust and safe laser control systems.

## BASIC TERMINOLOGY

In its most basic sense, the Ground is the point against which all other voltage values are *referenced*, and it is also the current return path to the power supply. In electronic circuits, both the reference and the current return path are necessary.

Before diving into a discussion of how to ground a laser control system, a discussion of nomenclature is in order. **Figure 1** illustrates the schematic representations of ground that will be used in this paper:

- **Earth Ground:** the Earth Ground is a safety ground and should carry current only in case of a fault condition, such as an internal insulation breakdown. Earth ground is critical for safety, and prevents the equipment from reaching dangerous or lethal potentials.
- **Signal Ground:** the Signal Ground is a low impedance current return path to the power supply. In **Figure 1** the analog signal ground is "floating" since it is not connected to the earth ground.

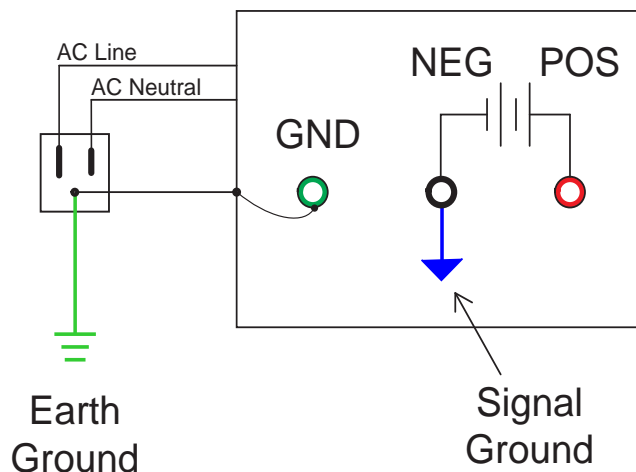
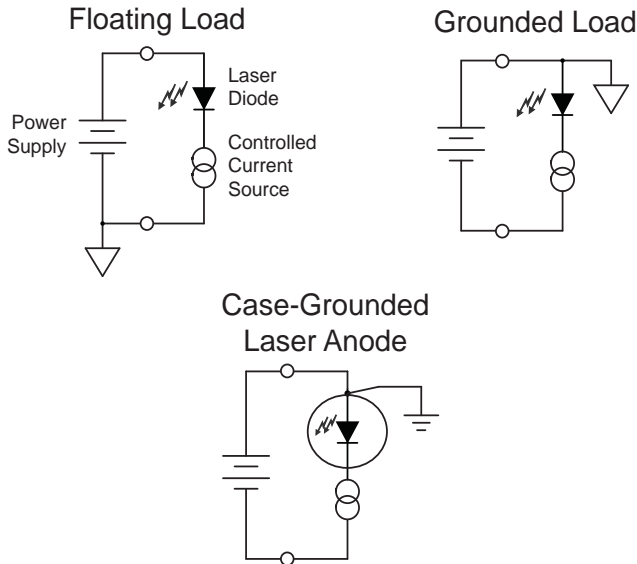


Figure 1. Definition of Ground Symbols

## LASER DRIVER GROUNDING OPTIONS

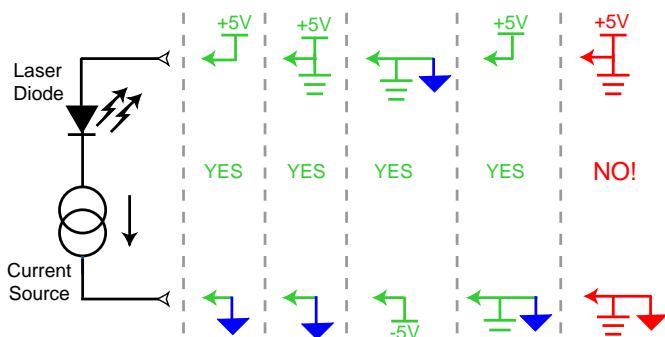
In most cases, grounding the laser diode and power supply is straightforward. **Figure 2** shows common power supply and ground configurations where the laser anode is connected directly to the power supply; this is a common configuration for commercially-available laser drivers.



**Figure 2. Three Typical Grounding Configurations**

The top two schemes are straightforward and present little risk of grounding conflicts. But the bottom configuration—the case-grounded laser anode—can be problematic if power supply-ground connections are made without first thoroughly investigating the circuit.

**Figure 3** shows common power supply and grounding schemes that are acceptable and one that is to be avoided.



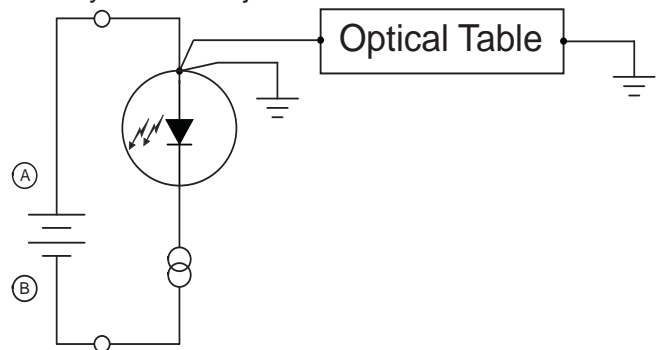
**Figure 3. Example Grounding Configurations**

## SAFELY GROUND THE LD ANODE

Connecting the laser diode anode to ground often gives the best low-noise performance.

Consider a lab situation using a laser with a case-grounded anode (**Figure 4**). The laser is placed in a metal mount and the optical bench is earth-grounded to help control electrical noise in the laser system. The net result is that the laser anode is earth-grounded which, by itself, is a perfectly acceptable configuration.

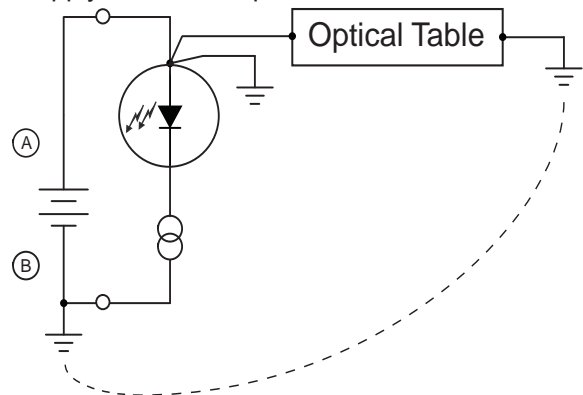
Point A, the positive terminal of the power supply, is at zero volts with respect to ground, and Point B is at a negative voltage. The net result is that the laser is positively biased, and the system works just fine.



**Figure 4. Earth-Grounded Anode**

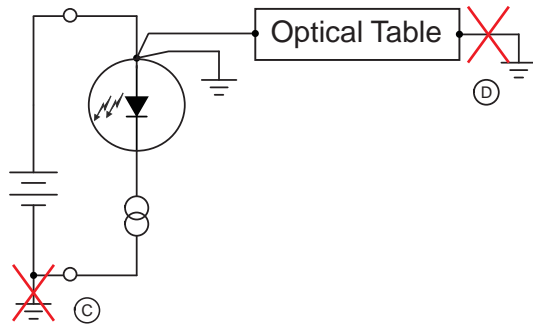
Earth-grounding the positive terminal of the laser driver power supply doesn't present a problem. But now that the *positive* terminal is earth-grounded, it is critical that the *negative* terminal not be connected to earth ground anywhere within the system. If that connection is made, the power supply is shorted directly to ground and it will blow a fuse, or worse.

**Figure 5** illustrates the problem—the dashed loop is the power supply short-circuit path.



**Figure 5. Problem: Grounded Anode & Power Supply**

- There are two solutions, illustrated in **Figure 6**:
- Eliminate the earth-ground connection at the power supply (point C), or
  - Eliminate the earth-ground connection to the optical table (point D).



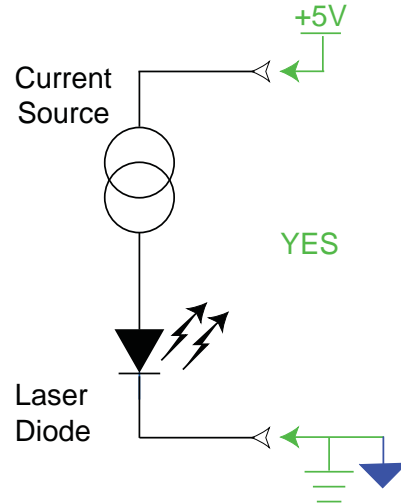
**Figure 6. Solution: Break the Ground Short at One Point (C or D)**

It is common practice to earth-ground the optical table in order to help reduce system electrical noise, and for safety reasons, so it's best to leave the ground at point D. The better option is to disconnect the earth-ground connection at the power supply (point C).

This configuration is often called Negative Power Supply Operation.

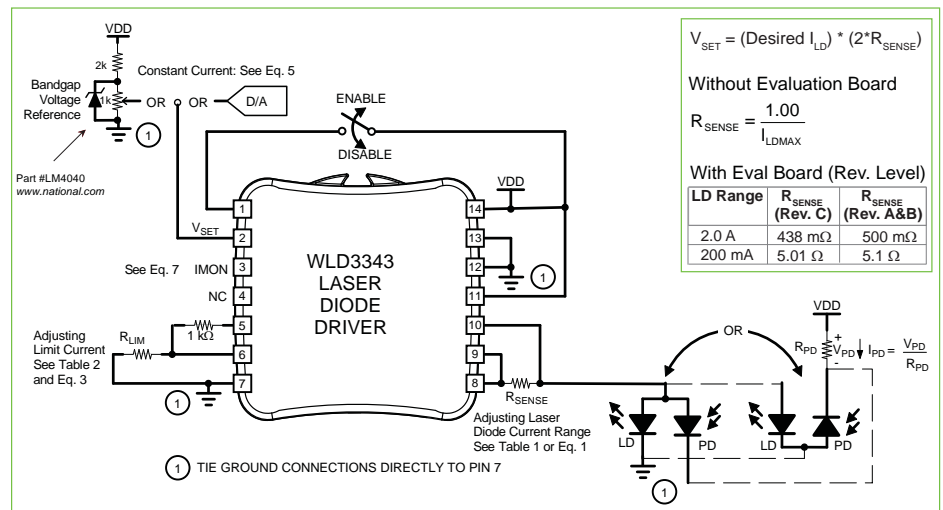
### SAFELY GROUND THE LD CATHODE

If the cathode of the laser diode driver must be grounded, there are two options. The laser diode driver current source can be positioned between the positive terminal of the power supply and the laser diode, as shown in **Figure 7**.



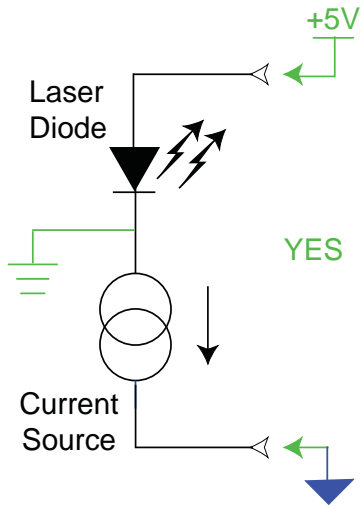
**Figure 7. Grounded Cathode & Power Supply**

Wavelength's WLD laser diode driver can be configured in this fashion. Wire the laser diode up as if it is a Type C laser in Constant Current mode, as shown in **Figure 8**.



**Figure 8. Type C Laser Diode with WLD3343 in Constant Current Mode**

In the second option, the laser diode power supply can be floated, or a battery can be used, as shown in **Figure 9**.



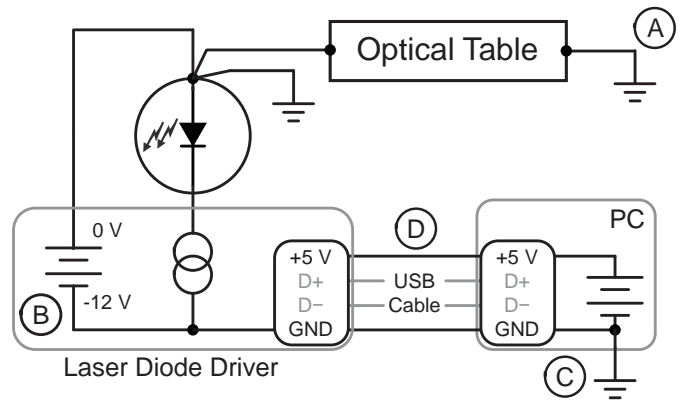
**Figure 9. Floating Power Supply**

## THE DANGER OF USB CONTROL

USB-connected test equipment has simplified life in the lab, but USB standards are designed for consumer electronics and can cause unexpected problems with electronic test equipment. The reason is that *the device connected to the computer must share the computer's ground connection via the USB cable and electronics*.

Consider the optical table configuration in **Figure 10**, with a PC controlling a laser diode driver. The laser anode is case-grounded, the laser case is electrically connected to the bench, and the table top is earth grounded. This is the same configuration identified in an earlier section, and since the power supply is floating all appears to be fine.

But there are two problems lurking, and they'll become evident at the instant the USB cable connection is made.



**Figure 10. Example Configuration with USB Control**

The USB connectors are designed so that the +5V and GND connections are made before the data connections. But in the real world, the individual +5V and GND pins connect at very slightly different times—even just a few milliseconds apart—and two different outcomes are possible:

- If the GND connection is made first, then both terminals of the laser power supply become connected to earth ground (Point A to C, through Point B). Either the power supply will blow a fuse, or the USB electronics will be damaged.
- If the +5V connection is made first, then the USB circuit in the laser driver is subjected to an over-voltage condition. The moment before connection, Point B is  $-12\text{ V}$  relative to earth ground and Point D is  $+5\text{ V}$  relative to earth ground. When the +5V connection is made there is an instantaneous  $17\text{ V}$  differential across the USB controller. The electronics are designed for a  $5\text{ V}$  environment, and  $17\text{ V}$  will cause damage.

The simplest solution to this problem is to electrically isolate the laser anode from earth ground. Either the optical table has to be electrically floated, or the laser case must be electrically isolated from the table.

Another solution is to break the laser driver-to-earth ground connection along the USB system using a USB bus isolator. These devices employ opto-isolators in the data lines, and break the +5V and GND connections. With a USB isolator, the laser anode can be safely connected to the earth-grounded optical bench.

A third option is to make the USB connection prior to powering the laser diode driver.



**NEVER ELIMINATE THE EARTH-GROUND CONNECTION OF THE COMPUTER.** ISOLATING THE COMPUTER FROM EARTH GROUND IS EXTREMELY DANGEROUS AND CAN RESULT IN DAMAGE, FIRES, OR POTENTIALLY LETHAL ELECTRICAL CONDITIONS.

Two additional benefits of USB isolators: one potential inadvertent ground loop path is eliminated; and the notoriously noisy computer circuits are isolated from the laser control electronics.

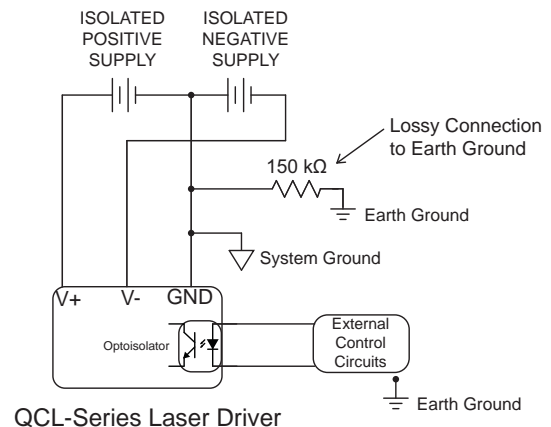
## DRIFTING GROUND POTENTIAL OF FLOATING POWER SUPPLIES

If neither terminal of the power supply is connected to earth ground, then the power supply is said to be “floating.” Power supplies are floated in order to avoid ground loops, or in the case of anode-grounded lasers, to avoid short-circuiting the power supply to ground.

Floating power supplies are susceptible to accumulating charge over time, and the circuit ground potential will drift relative to earth ground. It is possible for the potential of the isolated side to drift by tens of volts—or more—relative to the earth-grounded side. If there are electrical components connected to both the isolated side and the earth-grounded side, such as opto- or digital isolators, then the maximum isolation voltage ratings can be exceeded. The circuit shown in **Figure 11** is an example of such a configuration.

Connecting the grounds of the isolated power supplies to earth ground prevents the drift, but may cause ground loop current. The solution is to provide a high impedance path to drain the accumulating charge to ground.

**Figure 11** indicates a 150 kΩ resistor connecting the power supply analog ground to earth, when using Wavelength’s QCL driver. **This resistor is necessary if the electronics ground is tied to earth ground within the system, such as at a DAQ card, computer, or USB cable.**



**Figure 11. Lossy Connection to Earth Ground**

This resistor provides a lossy connection from the power supply system ground to earth ground, allowing accumulated charge to bleed to ground, and will prevent the isolated circuits from drifting relative to the rest of the circuit.

Choosing the resistor value is a balance: too low a value and there will be ground loop current that introduces noise into the system; too high a value and the power supply ground potential may drift.

## PUTTING IT ALL TOGETHER

A wide range of grounding topics have been discussed in this Application Note. All the concepts described are important to designing a safe and robust laser diode control system.

The most important idea to take away from this Application Note is that before power is applied to any system, the grounding scheme must be carefully and thoroughly examined. Perhaps the greatest caution is required when computers are added to the system, since the USB connection adds an often overlooked ground connection.

The best ways to ensure there are no accidental ground problems is to draw the system, component-by-component and including the interconnect cables, and then identify the connections to ground. Look for ground loops, multiple ground connections, and current loop paths, and if any are found correct them before powering up the system.

As with all other aspects of designing a complex system, a slow and methodical approach to the grounding scheme will pay off with faster development time, lower cost, and less trouble for the engineers.

## KEYWORDS

Laser diode controller, ground, ground loop, laser diode ground, laser anode ground, laser control system, laser diode control, floating power supplies, power supply ground, isolated power supply, lossy connection, laser cathode ground