TECH NOTE

LDX-3736 Laser Protection

OVERVIEW

The LDC-3736 Quantum Cascade Laser Controller is designed to safely drive quantum cascade lasers (QCLs) with up to 4 Amps of current and a compliance voltage of 18 Volts. QCLs are sensitive to rapid spikes in laser current level, also known as transients. QCLs are also sensitive to electrostatic discharge and excessively high laser current levels.

The LDC-3736 has been designed with multiple levels of laser protection in order to minimize exposure to electro-static discharge, overly high laser current levels, and transients. The laser protection system of the LDC-3736 Controller includes redundant current limits, output shorting relays, slow start and safe shutdown circuits, and safety interlocks.

REDUNDANT CURRENT LIMITS

The LDC-3736 incorporates a firmware and hardware current limit. When a current limit is set via the front panel or remote interface the value is stored in non-volatile memory. The firmware will not allow the user to set the current setpoint to a value greater than the current limit. The circuit also continuously monitors the laser current and compares it to the current set point. The LDC-3736 laser protection system will attempt to clamp the laser current if it detects it rising above the setpoint. If the laser current limit is exceeded despite the current clamping, the laser protection system will immediately short the output and disable the current source.

Similarly, the laser voltage is monitored and compared to the laser voltage limit setting using a comparator. If the output voltage is above the limit, the LDC-3736 will attempt to clamp the laser current so the laser voltage will not exceed the limit. If the limit is exceeded despite the current clamping, the laser protection system will immediately short the output and disable the current source. Figure 1 provides a schematic overview of the laser current and voltage limit protection of the LDC-3736.

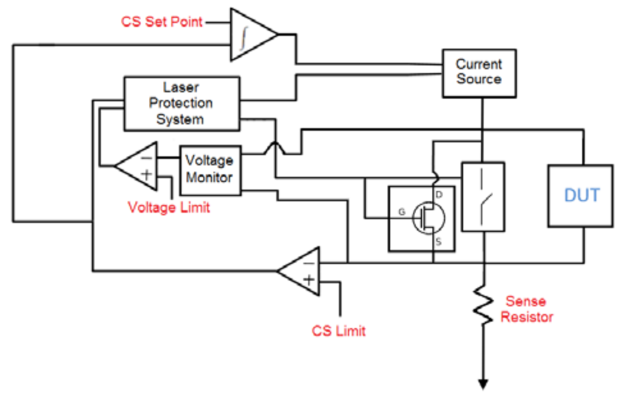

Figure 1: Schematic diagram of the LDC-3736 laser protection system circuitry

OUTPUT SHORTING SWITCHES

As seen in Figure 1, a normally closed mechanical shorting relay is placed across the device under test (DUT) to protect the quantum cascade laser during power up or power down. By shorting the output of the device, the leads are maintained at the same potential when the laser is not in operation. This feature is engaged even when the LDC-3736 output is off or AC power is lost.

In addition to the mechanical relay, a MOSFET is connected across the DUT to act as a fast-acting switch. If a current surge is detected, this MOSFET will shut to shunt any unsafe current away from the laser.

TECH NOTE

SLOW START AND SAFE SHUT DOWN

When the LDC-3736 output is enabled, the laser current output is slowly ramped up to minimize any potential for current or voltage overshoot due to a large DUT impedance. Figure 2 shows a screen capture demonstrating the slow current ramp.

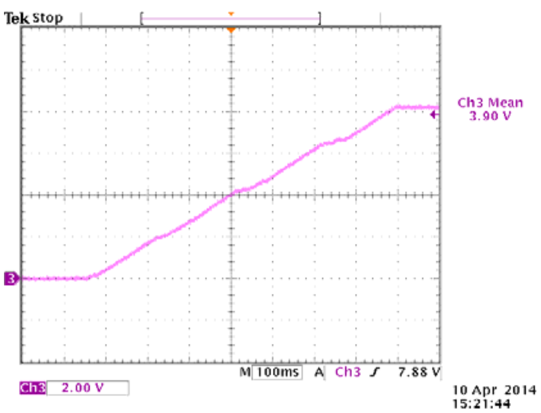

Figure 2: LDC-3736 slow ramp to 500 mA

Figure 3 shows the fast shut down of the LDC-3736 that occurs when the output is disabled through a limit condition or a safety interlock being tripped.

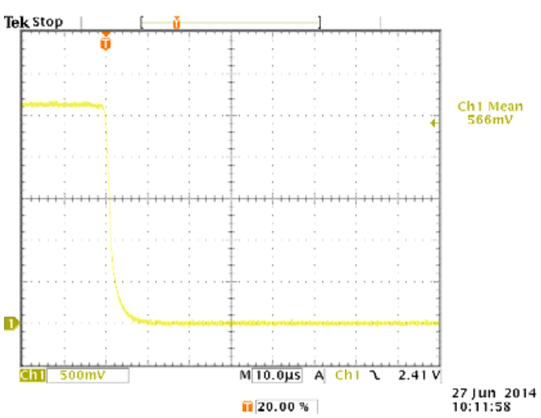

Figure 3: Fast shut down response of the LDC-3736

SAFETY INTERLOCKS

The LDC-3736 has two interlocks that will safely disable the output if tripped. One interlock is an internal thermoelectric temperature controller (TEC) interlock that will shut down the laser current if a TEC controller error occurs. The second interlock is a close-to-enable, open-to-disable circuit that is designed for compatibility with user interlocks, such as safety hood switches.

TRANSIENT PROTECTION

Transients, including operational and power line transients, were tested by connecting a LDC-3736 to a fiber-coupled laser. The laser output was measured by a reverse-biased New Focus model 1811 high speed photodetector. The photodetector signal was monitored with a Tektronix TDS-3014 oscilloscope. The setup was similar to the arrangement used in the ILX Lightwave whitepaper “A Standard for Measuring Transient Suppression of Laser Diode Drivers”.

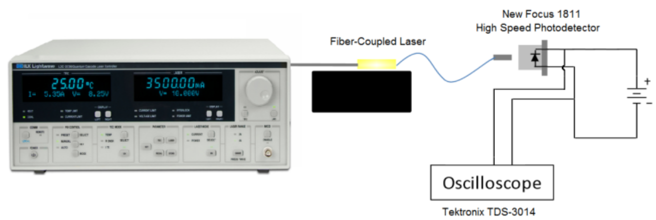

Figure 4: Schematic of transient testing of the LDC-3736 Quantum Cascade Laser Controller

No transients were measured during normal LDC-3736 operation. Figure 5 shows a loss of power/brown out condition transient. The laser shutoff condition shown is identical to the normal output shut down shown in Figure 3, but is shown with a smaller time interval per square in order to capture any possible laser current transients on the plot. No transients were noted in this plot.

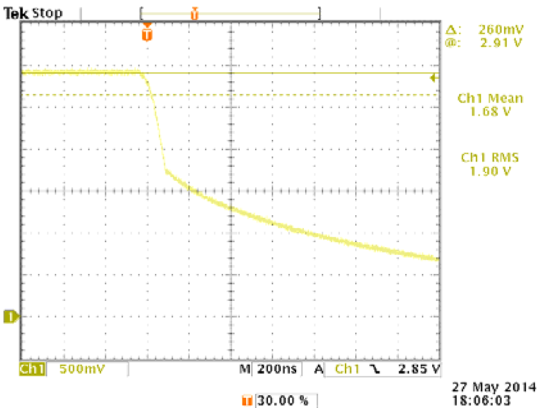

Figure 5: LDC-3736 laser current disabled due to loss of power or brown out

Figure 6 shows the measurement of laser current transients during a 1 kV electronic fast transient (EFT). The EFT occurred just before the time marked by the orange arrow. As shown, the laser protection system was able to avoid having any excessive laser current change despite the EFT occurrence. The measured transient on the laser output for the plot below was 12.7 mA, which is below the allowable 15 mA EFT noise specification for the LDC-3736.

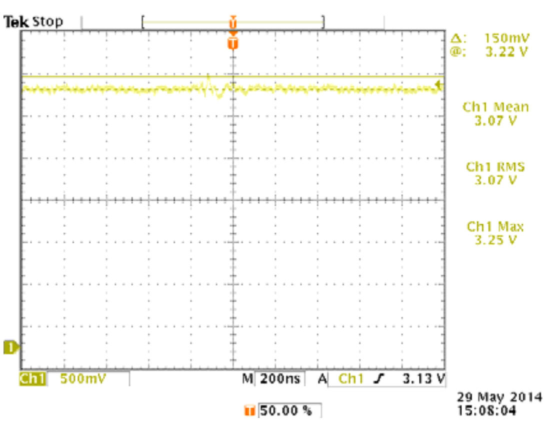

Figure 6: Effect on laser output due to 1 kV EFT event on AC power line

Figure 7 shows the transient during a 1 kV power surge. The power surge occurred at the time marked by the orange marker in the screen capture. As shown, the laser protection system was able to avoid any excessive laser current change despite the power surge. The measured surge on the laser output for the plot below was 3.6 mA, which is below the allowable 8 mA power surge noise specification for the LDC-3736.

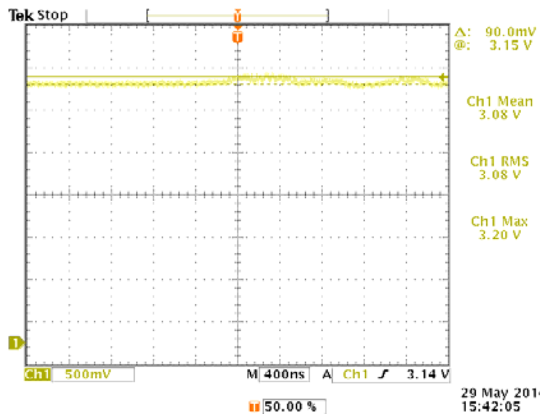

Figure 7: Effect on laser output due to 1 kV power surge event on AC power line

Intermittent contact occurs when a connection between the laser and the LDC-3736 is quickly broken and remade. This can occur due to the connection cables being improperly connected to the LDC-3736 or due to poor contact between the laser pins and the laser mount. Figure 8 shows an intermittent contact event, with the yellow trace showing the voltage on the output cable and the blue trace showing the optical output of the laser.

TECH NOTE

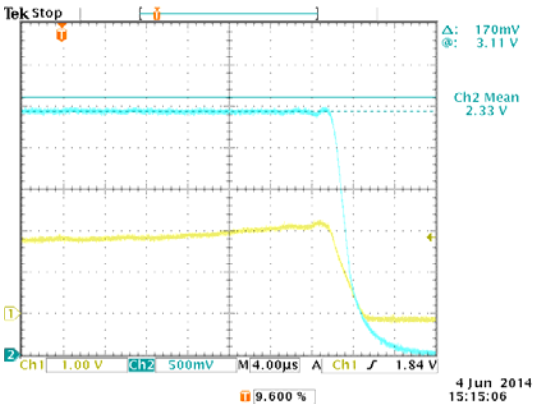

Figure 8: Intermittent contact response of the LDC-3736 with appropriate voltage limit setting

As shown, when the intermittent contact occurs, the controller will first try to increase the voltage output to maintain constant current as the contact begins to break, but will quickly detect the rapid change in contact resistance and shut down the current output to protect the laser. In this case the laser voltage limit is set to 2.0 Volts, just above the 1.68 Volt operating voltage of the laser shown on the laser datasheet. This setting allowed the system to shut off the output quickly and no transients were measured. If the laser voltage limit is not set properly, some current transients may occur. This is shown in Figure 9, where the voltage limit is set to 10.3 Volts, well above the laser operating voltage of the laser.

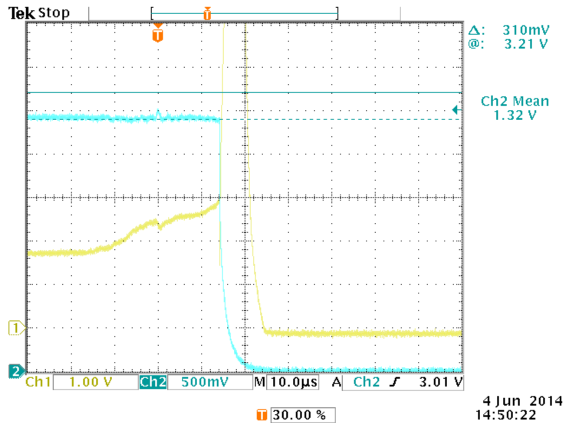

Figure 9: Intermittent contact response of the LDC-3736 with improper voltage limit setting

In Figure 9, the yellow voltage trace shows the voltage increasing much higher than the operating voltage for the laser as the contact resistance increases to maintain constant current. When the connection is remade the cable resistance decreases and there is a transient seen in the blue laser output trace. The measured current transient in this case was less than 17 mA. Although this is a small current transient, it is safer for the laser if the voltage limit is set close to the laser operating voltage to avoid any over current conditions.

CONCLUSION

The multiple levels of laser protection designed into the LDC-3736 Quantum Cascade Laser Controller will protect QCL devices during normal operation and under strenuous operation.

For additional information on safe operation of laser diodes and quantum cascade lasers, please see ILX Lightwave Application Note # 3: Protecting Your Laser Diode.