HIGHLAND TECHNOLOGY

MODEL D200

DIODE LASER DRIVER

Technical Manual

January 31, 2023

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Table of Contents

1 *Introduction*

This is the technical manual for the Highland Model D200 Laser Driver.

Features of the D200 include:

- Selectable DC-coupled input follower or pulse generator modes
- Built-in edge-triggered pulse generator, up to 1 microsecond width
- Laser drive current up to 4 amps, 0 to 100% duty cycle
- Rise / fall times, 2 nanoseconds, typical
- Thermal protection
- Low inductance laser connections are suited to direct laser connection, or attachment to interposer boards or flex transmission lines
- Highly stable constant-current laser drive
- Laser current and pulse widths are set by onboard trimpots or external analog inputs
- Powered by 6 to 12 volts through 2.1 x 5.5 mm barrel connector, or ribbon cable interface connector
- 4-inch x 4-inch PCB for embedded application
- Compatible with Highland models

  P500 4-channel benchtop digital delay and pulse generator

  T660 4-channel compact digital delay and pulse generator

The very high speed components of the D200 are sensitive to electrostatic damage. To maintain picosecond performance, no explicit ESD protection is included.

Discharge cables before connecting to the D200. Do not apply trigger inputs over 3.3 volts.

Baseplate heatsinking is required for laser outputs above 2.5 amps with 5 volt supply, and 0.8 amps with 12 volt supply.

2 *Specifications*

Specifications are typical unless otherwise noted.

FUNCTION	Diode laser driver with internal pulse width generator
TRIGGER INPUT	Switchable single-ended (SE) or differential SE Threshold is fixed 0.4 volts, 50 ohm load Differential input is LVDS / ECL / LVPECL / CML, 100 ohm load Pulse mode trigger rate, 0 to 30 MHz; min trigger width 1 ns Follower mode trigger rate, 0 to 100 MHz
PROPAGATION DELAY	5 ns, typical, follower range 13 ns, typical, narrow-width range 35 ns, typical, medium-width range 276 ns, typical, wide-width range
INTERNAL PULSE GENERATOR	Pulse mode triggers on input rising edge Width adjustable up to 1 µs in 3 ranges
LASER DRIVE OUTPUT	0 to 4 amps adjustable Current source compliance supports up to 9 volt lasers Current source program accuracy variation < 1% Duty cycle 0 to 100%
RISE/FALL TIMES	2 ns nominal
JITTER	15 ps RMS, typical, ≤ 40ps RMS, guaranteed, narrow-width range 35 ps RMS, typical, ≤ 100ps RMS, guaranteed, medium-width range 175 ps RMS, typical, ≤ 500ps RMS, guaranteed, wide-width range
CONTROL	Two trimpots or analog inputs set laser ON current and pulse width Analog inputs are 0 to +5 volts, 1.5 KΩ load Follower / pulse mode is switch selected Pulse width range is switch selected
OPERATING TEMPERATURE	-20° C to +60° C, non-condensing Self-resetting over-temperature shutdown
POWER	+6 to +12 volts via barrel connector or ribbon header Current consumption: 5.5 amp max
CONNECTORS	Single-ended input: SMB connector LVDS / PECL, control, power: 10-pin 50-mil 2x5 ribbon cable header MONITOR output: SMB connector Power: 2.1 x 5.5 mm barrel connector, center pin positive
LED INDICATORS	Orange POWER

PACKAGING	4” x 4” printed circuit board, installed on 6” x 6” aluminum baseplate

3 *Architecture*

The ribbon cable grounds, the PCB ground plane, the SMB shells, and the mounting holes are all electrically connected.

The signal path of the D200 is shown below:

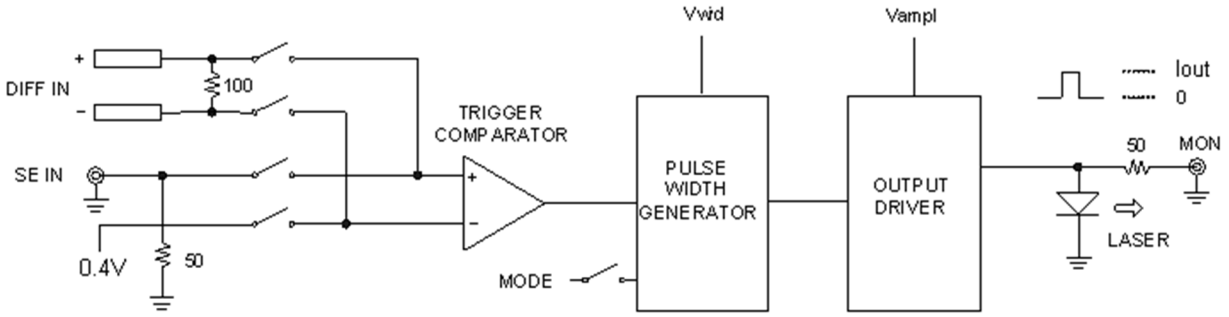


Figure 1: D200 Signal Path

The choice of single-ended or differential input trigger is switch selectable.

Follower/pulse generator mode is also a switch option. In follower mode, the D200 output matches the logic level of the input. In pulse generator mode, a rising input edge triggers the D200. The duration of the output is determined by *Vwid*.

Vampl programs ON laser current.

The output driver topology is as follows:

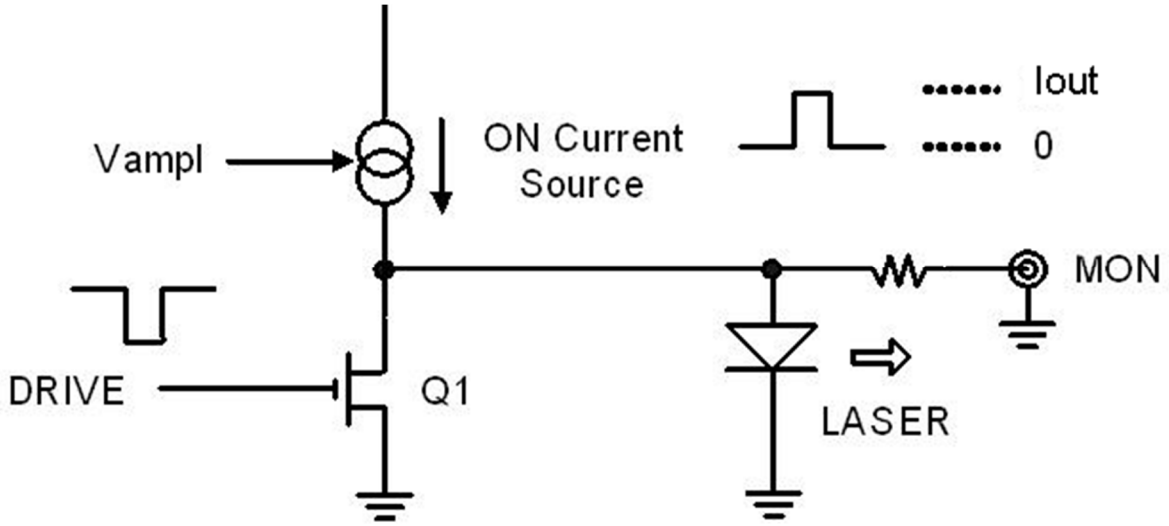


Figure 2: Output Driver Topology

The main current source is on continuously. When the trigger input level is below threshold or pulse generator is off, Q1 is ON and diverts this current to ground. Active pulse drive turns Q1 off, allowing the current source to drive the laser. At the end of a laser pulse, the laser anode is driven hard to ground, ensuring sharp turnoff and minimal optical tails.

The D200 has no provision for off-state laser bias. In follower mode at high data rates, some optical pulse width distortion may occur.

Laser waveforms can be monitored with an oscilloscope at the *MON* connector.

4 *Connections and Installation*

4.1 *Trigger Input*

The D200 is switchable for single-ended (SE) or differential input options.

SE input is available on the SMB connector labeled *TRIG*. The D200 terminates this input with 50 ohms to ground. Input threshold is fixed at +0.4 volts, which is compatible with most TTL, ECL, LVPECL, and CML drivers, and with fast pulse/clock/arb generators.

Differential LVDS / PECL inputs are available on the P1 ribbon cable connector, with 100 ohm differential termination. Common-mode voltage should be in the range of -1 to +3.3 volts which accommodates most LVDS, ECL, PECL, and CML sources. Minimum differential input swing is 200 millivolt peak-to-peak.

4.2 *Ribbon Cable Connector*

P1 is a 50-mil-pitch, 10 pin, male 5 x 2 ribbon cable connector. It can be used to apply power, control, and differential trigger signals to the D200. The PCB header is Samtec # FTSH-105-01-L-D-K, and mates with Samtec FFSD series connectors. A convenient method of connecting to the D200 ribbon header is with a readily available, pre-fabricated ribbon cable assembly. The ribbon cable can be cut in half, providing two ribbon connector pigtails. A useful, 12-inch cable assembly is the Samtec # FFSD-05-D-12.00-01-N, available from Digikey as # SAM8219-ND.

If control inputs are applied via P1, turn respective trimpots fully counter-clockwise.

The pinout is:

PIN	NAME	FUNCTION
1	+V	Power Input
2	+V	Power Input
3	*Vampl*	Laser ON current program
4	Reset	Active-low output inhibit
5	Ground	
6	TRIG+	Differential input +
7	TRIG-	Differential input -
8	Ground	
9	Ground	
10	*Vwid*	Pulse-width program

Table 1: 10-pin ribbon header pin assignment

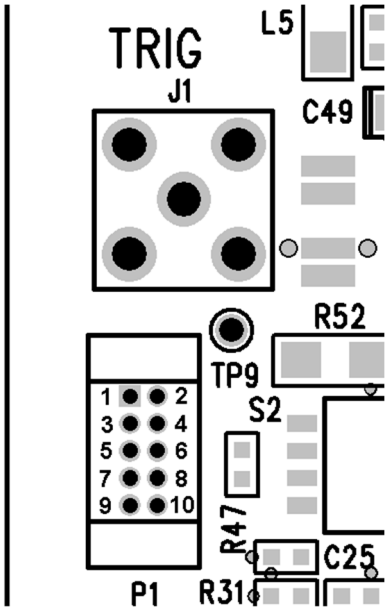


Figure 3: P1 numbering

It is recommended that all +V and Ground pins be used to minimize voltage drop in the ribbon cable. The voltage at TP10 must not drop below +5.4 volts to maintain normal operation.

Vampl is an analog input which sets the laser drive current, namely the current applied to the laser during an active pulse. An input range of 0 to +5 volts sets the laser drive current from 0 to 4 amps, respectively.

The *Reset* pin shuts off the output driver when grounded. During power-up, an onboard power supervisor asserts Reset, preventing spurious laser drive.

Vwid controls the pulse width. Pulse width ranges from zero to maximum for applied voltage between +1.8 volts and +5 volts on the *Vwid* pin. A dip switch on the board (S1) sets the maximum nominal width to 20 nanoseconds, 100 nanoseconds, or 1 microsecond.

4.3 *Trimpot Operation*

Two trimpots are provided for use when P1 ribbon-cable programming is not used. The *ISRC* trimpot sets laser drive current with a range spanning 0 to 4 amps. The *WIDTH* trimpot sets pulse width. Depending on the width range selection, the useable span is 0 to 20 nanoseconds, 20 nanoseconds to 100 nanoseconds, or 100 nanoseconds to 1

microsecond. Rotating a trimpot clockwise results in an increase of the associated parameter.

Set any pot counter-clockwise when P1 ribbon-cable programming is used for that function.

4.4 *Dipswitch Settings*

The D200 utilizes DIP switches for trigger and pulse / follower mode selection.

Dip switch S2 selects single-ended (SE) or differential input. The following table describes how to configure S2 for the desired input setting:

Input Trigger	**Switch Position**			
	S2-1	**S2-2**	**S2-3**	**S2-4**
Single-ended	ON	OFF	OFF	ON
Differential	OFF	ON	ON	OFF

Table 3: Input Trigger selector switch (S2) configuration

Dip switch S1 selects how the D200 responds to trigger events, either as an edge-sensitive pulse generator or as a pulse follower. If set as a pulse generator, S1 also sets the pulse width range.

The following chart describes how to configure S1 for the desired mode:

Output Mode / Width Range	**Switch Position**			
	S1-1	**S1-2**	**S1-3**	**S1-4**
0 – 20 ns	OFF	OFF	-	ON
20 – 100 ns	ON	OFF	-	ON
100 ns – 1 µs	ON	ON	-	ON
FOLLOWER	-	-	-	OFF

Table 4: Pulse switch (S1) configuration

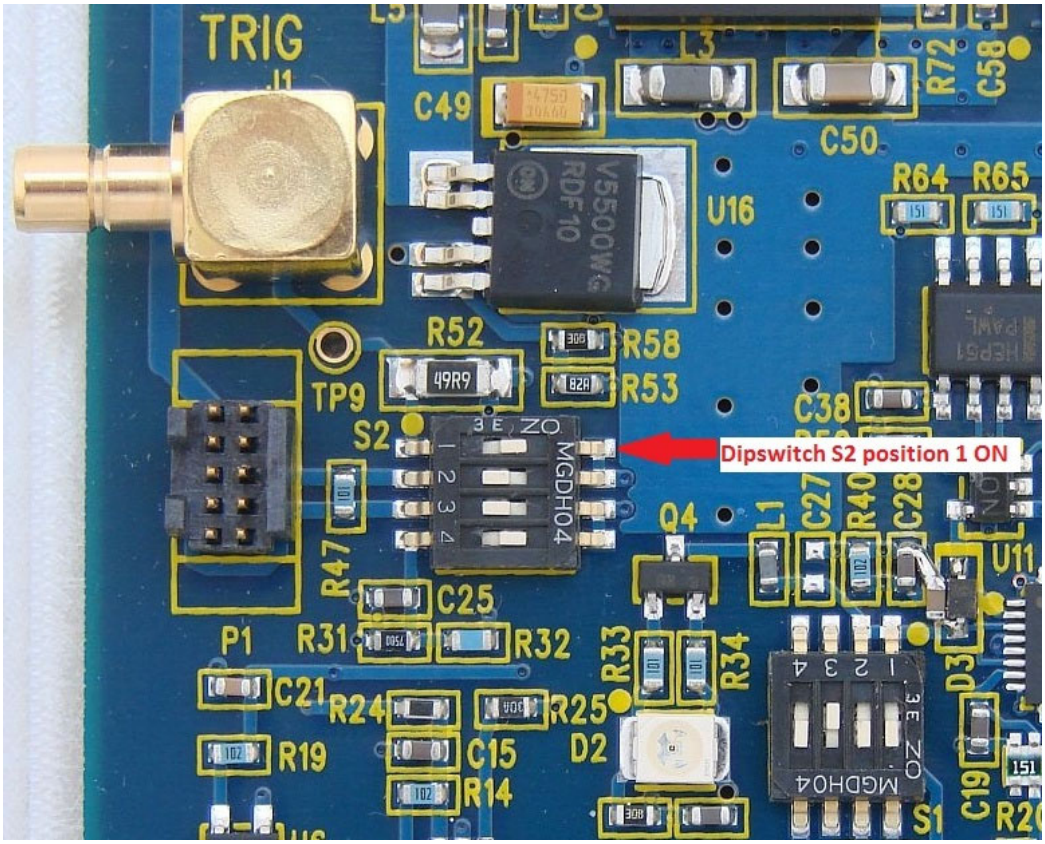


Figure 4: S1 and S2 DIP switch locations

4.5 *Monitor Connector*

MON is an SMB connector used to monitor laser waveforms with an oscilloscope. It connects to the laser anode through a 450 ohm resistor. The 450 ohm sampling resistor acts as a 1:1 source terminator into a high impedance scope, or a 10:1 divider with a 50 ohm oscilloscope. MON can also be used as a very low jitter oscilloscope trigger when viewing optical waveforms.

4.6 *Laser Connections*

Three large, rectangular, gold-plated pads are provided to connect the laser to the topside of the PCB. The center pad is the laser anode drive, and the two outer pads are ground. Each cathode connection has two #2 screw clearance holes that align with tapped #2-56 threads in the evaluation kit baseplate. The anode connection consists of three #2-56 threaded inserts, captive to the bottom of the D200 PCB. A grounded cathode pad is exposed on the backside of the PCB and should be bolted directly to the machined baseplate.

The D200 output current can slew as fast as 2 amps per nanosecond. Care must be taken to minimize excess inductance between the D200 and laser; every nanohenry of inductance can result in a 2 volt spike during a pulse. Excessive inductance in the laser drive path will create an L/R time constant that can significantly slow the laser turn-off transition, due to low junction impedance of a typical laser diode. Minimizing excess inductance will also help to reduce circuit ringing that can result from inductor-capacitor resonance at laser turn-on.

The D200 includes a peak-limiting diode to protect the output drivers from excessive inductive fly-back overshoot voltage, should the D200 be operated without a load connected.

A resistor load can be utilized as a laser substitute. The sum of all voltage drops must not exceed the current source compliance limit, nominally 3 volts less than the supply voltage.

The D200 can be operated indefinitely into a shorted load without damage.

All mounting holes, including the laser cathode, should be hard connected to the mounting block. This minimizes laser cathode inductance.

Laser anode connections can be made with multiple, very short leads or wirebonds, to the anode pad of the D200. A wire-bondable interposer, bolted onto the anode pad, is recommended.

If the laser cannot be mounted very close to the D200, a rigid or flex interposer PCB can be used. It must be a short, very low-impedance transmission-line structure. An EM simulator should be used to derive a transmission-line model for the interposer, followed by EM or Spice simulation to predict driver voltage and laser current waveforms.

Laser connections or interposers may limit laser rise / fall times.

4.7 *Mounting and Cooling*

The D200 is provided with five #4-40 sized (0.120-inch diameter) mounting holes. It is recommended that it be bolted to an aluminum block such as the baseplate provided in the D200 evaluation kit.

When the D200 is mounted to the evaluation kit baseplate, the three anode screws are exposed on the underside and must not be shorted in any way to the baseplate.

The D200-9 evaluation kit utilizes seven #2-56 anode mounting screws.

An electrically insulating, thermally conductive material should be placed between the bottom of the PCB and the mounting surface to provide conductive cooling in the vicinity of Q8, Q9, Q11 and Q12. Applying additional airflow can extend the maximum program current. Refer to Figures 5 and 6 for details.

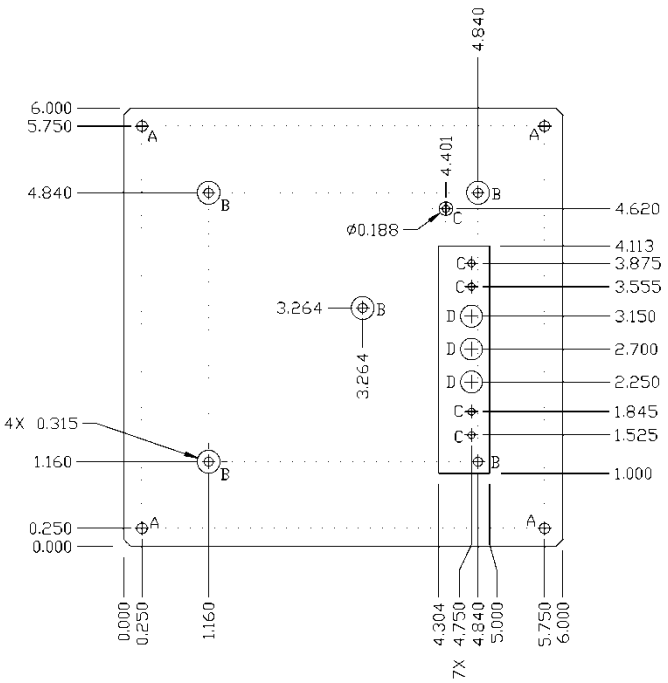


Figure 5: Evaluation Kit Baseplate dimensions

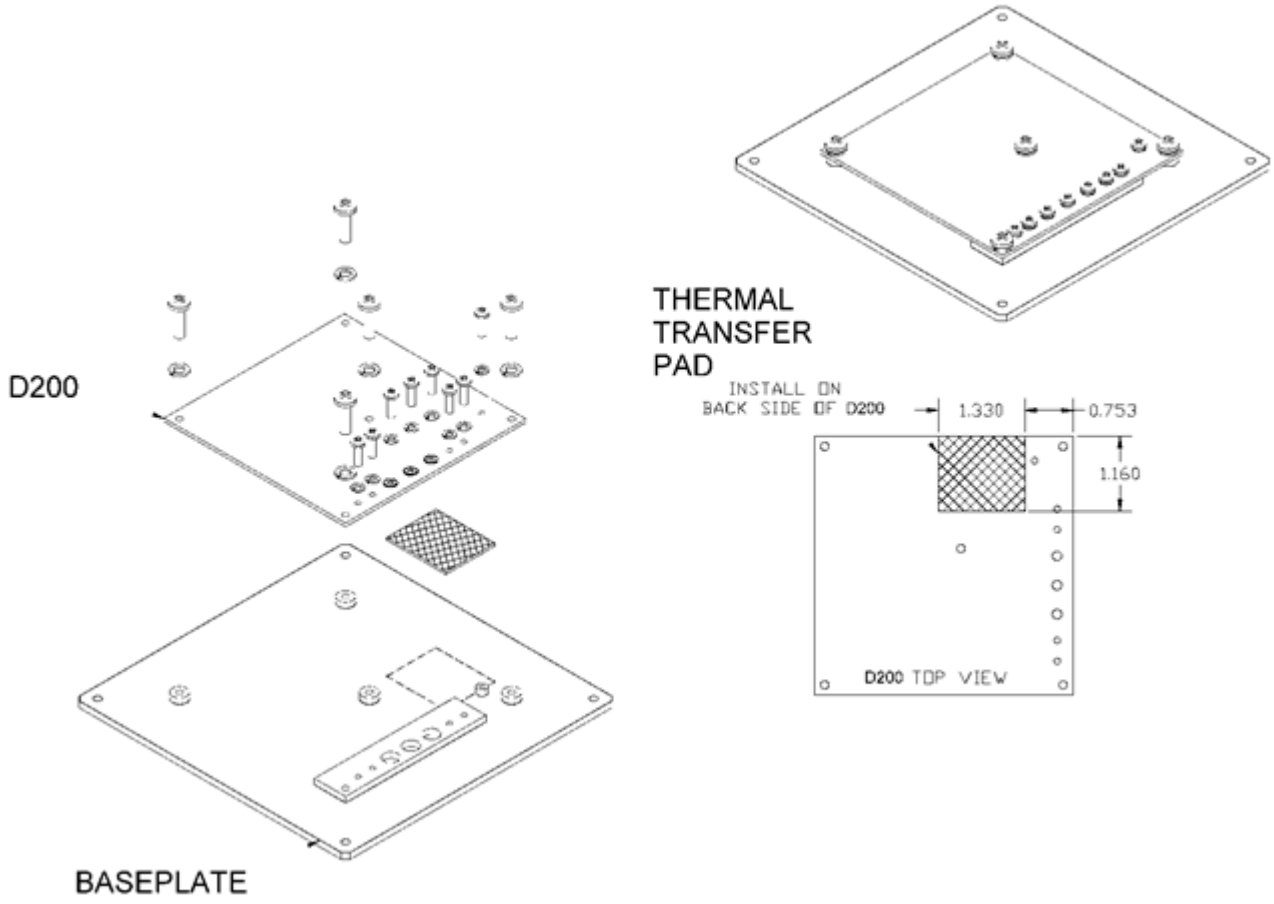


Figure 6: D200 Assembly on Baseplate

5 *Performance*

5.1 *Power*

The D200 dissipates approximately 7 watts quiescently. Onboard switching regulators reduce the quiescent current draw at higher voltages. Laser drive current is added to the quiescent current. For example, if a D200 is powered from a 6 volt supply, and set to source 1 amp, the total current consumption would be 2.2 amps.

D200 Supply Voltage (Volts)	D200 Quiescent Current Draw (Amps)
+6	1.20
+7	0.86
+12	0.55

Table 2: D200 baseline current draw

5.2 *Laser Drive Current Source*

The 0 to 4 amp laser drive current supply consists of two, summed, 0 to 2 amp current sources with local feedback. Both current sources are controlled together through the *ISRC* trimpot or *Vampl* ribbon cable pin. The total laser drive current, *ISRC*, is determined by measuring the voltage drop across either 0.1 ohm sense resistor (R82, R91) test points:

$$ISRC_{R82} = 20 * (V_{TP14} - V_{TP15})$$

or

$$ISRC_{R91} = 20 * (V_{TP16} - V_{TP17})$$

5.3 *Current Source Compliance*

The laser drive compliance is the maximum voltage that can be developed across the current source and maintain stable, linear operation. In practice, a laser's forward voltage drop should be less than or equal to the current source compliance voltage limit. In order to maintain regulation over the full -20° C to +60° C temperature range, +6 volts to +12 volts supply voltage range, and 0 to 4 amp *ISRC* laser drive range, the supply voltage should be at least 3 volts above the anode voltage. Please note that high-compliance applications can result in an increased output current risetime. Please refer to Table 5 below for dissipation limits.

5.4 *Propagation Delay*

The time delay between the rising edge of a qualified, above threshold input trigger signal and the rising edge of the D200 output current is called propagation delay. This delay is dependent on how the D200 is configured to translate trigger signals. Follower mode exhibits the lowest propagation delay. The delay in pulse mode depends on the width range setting. Please see Section 2 for details.

5.5 *Dissipation Limits*

The D200 can be operated safely without a heatsink throughout the entire specified temperature and power supply range for laser drive currents ≤ 0.5 amps. Operating the D200 at laser drive currents greater than 0.5 amps is conditionally limited depending on the power supply voltage, ambient temperature and cooling provisions.

The D200 may be operated across the entire temperature range at up to 1.3 amp laser current and a 6 volt supply without air cooling or baseplate. Higher currents require that the board be conduction cooled to a metal mounting block using a compliant thermal transfer pad. For example, the D200 can safely dissipate up to 30 watts when mounted to the baseplate (provided with the evaluation kit) when provided 1000 LFPM airflow.

The use of a current-limited power supply can help protect the D200 from excessive thermal dissipation. For example, the J206 power supply that is included in the D200-9 evaluation kit current limits at 2.5 amps, equivalent to about 15 watts of dissipation. Since the D200 draws approximately 1.2 amps quiescently at 6 volts, the maximum laser current is around 1.3 amps. Increasing the laser current setting beyond this will result in the J206 power supply shutting down.

The following table summarizes thermal operating limits and conditions:

<table>
<tr><th>Configuration
(-20°C to +60°C ambient temperature)</th><th>Power Supply Voltage</th><th>Laser Current (absolute max)</th><th>Power Dissipation (PCB)</th></tr>
<tr><td>D200 Bare PCB</td><td>+ 6 V
+ 9 V
+12 V</td><td>1.3 A
0.8 A
0.5 A</td><td>15 Watts</td></tr>
<tr><td>D200 + 1000 LFPM Airflow</td><td rowspan="2">+ 6 V
+ 9 V
+12 V</td><td rowspan="2">2.1 A
1.3 A
1 A</td><td rowspan="2">20 Watts</td></tr>
<tr><td>D200 +
Baseplate</td></tr>
<tr><td>D200 + Baseplate + 1000
LFPM Airflow</td><td>+ 6 V
+ 9 V
+12 V</td><td>4 A
2.4 A
1.7 A</td><td>30 Watts</td></tr>
</table>

Table 5: D200 maximum dissipation limits

6 *Basic Operation*

6.1 *Evaluation Kit*

The D200 evaluation kit includes a mounting plate / heatsink, power supply, and associated cabling. The evaluation kit is recommended for those experimenting with laser performance under varying electrical conditions, such as research and development applications. OEM versions are also available for integration into existing systems.

6.2 *Initial Power-up*

Check that the D200 *ISRC* trimpot is rotated fully counterclockwise before applying power to the D200. When power is applied to the D200, an orange onboard LED will illuminate.

6.3 *Connecting the D200*

a) Start with the power supply disconnected. Connect the D200 trigger input to a suitable trigger source. For most applications, this connection is made with a 50 ohm SMB coax cable to the Single-ended, TTL *TRIG* input jack.

b) Configure the input trigger DIP switch (S2); set S2-1 and S2-4 ON and S2-2 and S2-3 OFF for single-ended TTL trigger sources. Refer to Section 4.4.2 for details.

c) Connect the laser to the D200. Reduce lead lengths to minimize parasitic circuit inductance that can diminish performance. Refer to Section 4.6 for details.

d) Connect the power source to the D200. The Highland Technology Model J206, 6 volt supply included in the D200 evaluation kit is recommended.

e) Set up necessary instrumentation equipment that will permit observation of the laser. Typical equipment includes a pulse generator as a trigger source, a photodetector & oscilloscope to resolve amplitude and time domain behavior, and an optical spectrum analyzer to resolve emission spectra.

f) Couple the laser to the detection equipment. Connectorized, fiber-coupled lasers are convenient to work with, because they provide a stable method of transporting light directly from the laser to the photodetector.

6.4 *Pulse Mode Quickstart*

The D200 can be configured to operate as an edge-sensitive pulse generator, capable of driving lasers with 0 to 1 microsecond pulse widths. The following procedure is recommended to get started using the D200 in pulse mode using an oscilloscope and photodetector:

a) Set the D200 pulse mode selector switch to pulse mode by sliding S1-4 ON.

b) Select the appropriate D200 width range for pulse mode operation by setting S1. Refer to Section 4.4.2 for details.

c) Rotate the pulse *WIDTH* trimpot fully clockwise for the widest laser drive pulse in the selected width range, enabling easier waveform location on the oscilloscope.

d) Set the laser drive current trimpot *ISRC* to a nominal current that is compatible with the laser being evaluated. The nominal laser drive current is calculated by using a

digital volt meter to measure the voltage drop across either 0.1 ohm sense resistor test points: TP14 & TP15 for R82, or TP16 & TP17 for R91.

Laser ON current is equal to 20 * V_R , where V_R is the measured voltage across R82 or R91.

e) Activate the trigger source and locate the optical waveform on the oscilloscope.

f) Begin narrowing the laser drive pulse by *slowly* rotating the WIDTH trimpot counterclockwise until the desired pulse width is obtained.

6.5 *Follower Mode Quickstart*

The D200 can be configured to operate as a DC-coupled pulse follower. This mode of operation provides current to the laser, whenever the input trigger level is above threshold. Full continuous wave (CW) operation is supported with this mode. The following procedure is recommended for operating the D200 as an input follower:

a) Set the pulse mode selector switch to follower mode by sliding S1-4 OFF. The switch positons of the other sections of S1 are non-functional in this mode.

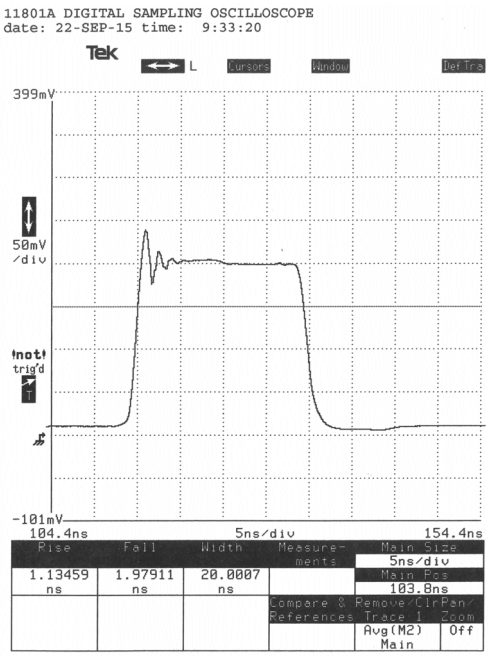
b) Set the laser drive current trimpot *ISRC* to a nominal current that is compatible with the laser being evaluated. The nominal laser drive current is calculated by using a digital volt meter to measure the voltage drop across either 0.1 ohm sense resistor test points: TP14 & TP15 for R82, or TP16 & TP17 for R91.

Laser ON current is equal to 20 * V_R , where V_R is the measured voltage across R82 or R91.

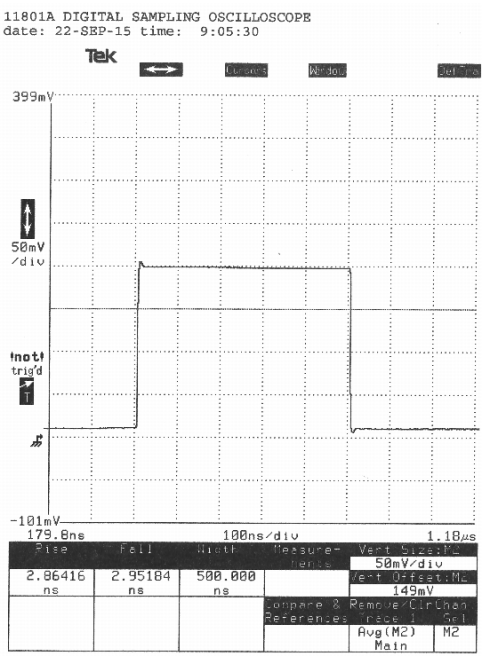
c) Activate the trigger source and locate the optical waveform on the oscilloscope.

d) Begin narrowing the laser drive pulse by adjusting the trigger source pulse width until the desired optical pulse width is obtained.

Typical pulsed output waveforms:



2A, 20ns pulse into 1Ω Load



2A, 500ns pulse into 1Ω Load

7 Dimensions

The three anode mounting screw locations contain pressed-in #2-56 threaded inserts, extending 0.187-inches below the bottom PCB surface. Care must be taken so that these screws do not make electrical contact with anything below the PCB.

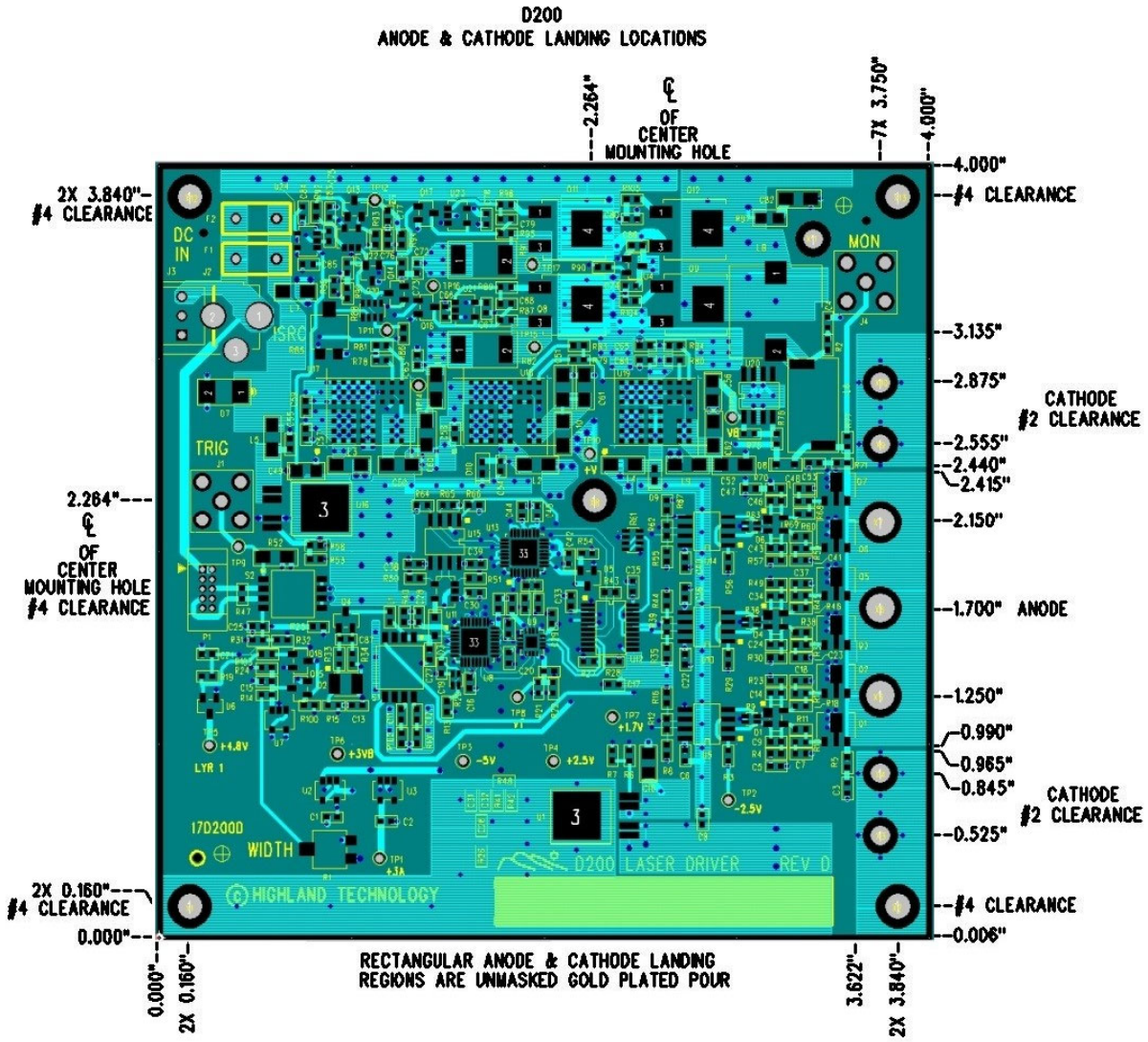


Figure 7: D200 layout and dimensions

8 *Versions*

Standard versions include:

D200-9: picosecond laser diode driver evaluation kit (includes D200-1, J206-1 universal 6V power supply, two J53-1 3’ SMB to BNC cables, baseplate, thermal transfer pad, and hardware)

9 Customization

Consult factory for information about additional custom and OEM versions, or for custom PCB laser interposer boards.

10 Hardware Revision History

Revision D January 2018
Functionally equivalent to Revision A
Added thermal protection and suppressed output upon power-cycle

Revision C November 2017
Functionally equivalent to Revision A
Added thermal protection and suppressed output upon power-cycle

Revision B April 2017
Functionally equivalent to Revision A
Improved manufacturability

Revision A July 2015
Initial PCB release

11 Accessories

J12-1: 12 volt power supply

J53-1: 3’ SMB to BNC cable (two included with purchase)

J206-1: 6 volt 2.5 amp power supply (included with purchase)