

# REVISIONS

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# 1 Overview

The 785A laser diode driver is a high power, medium speed, analog current source driver. It is designed to be driven by a group of analog and digital signals. It has status outputs which are also both analog and digital. The ripple and noise are much superior to those of a switching driver. The 785A is capable of operating with arbitrary waveforms.

## 1.1 Description

The driver has 5 basic subsystems. Refer to Figure 1: Block Diagram [Block Diagram](#).

1. The diode driver.
2. The input signal processing system.
3. The protection/fault system.
4. The enabling system.
5. The monitoring system.

### 1.1.1 Input Processing

This subsystem normalizes the input impedance and performs input scaling. It also contains provisions for activating and deactivating the Drive Control Input. When the Pulse Source is high a scaled version of the Drive Control Input is applied to the driver.

### 1.1.2 The Enabling System

The Enabling system normalizes the Enable input. It provides three principal operating functions:

1. Implement the Boolean function:  $\text{Enable\_out} = \text{Enable\_in} \text{ AND NOT}(\text{Fault})$ .
2. Generate a reset signal for the fault latch. The latch is reset when the Enable/Disable input switches from High to LOW.
3. Level shift the signals to perform their function.

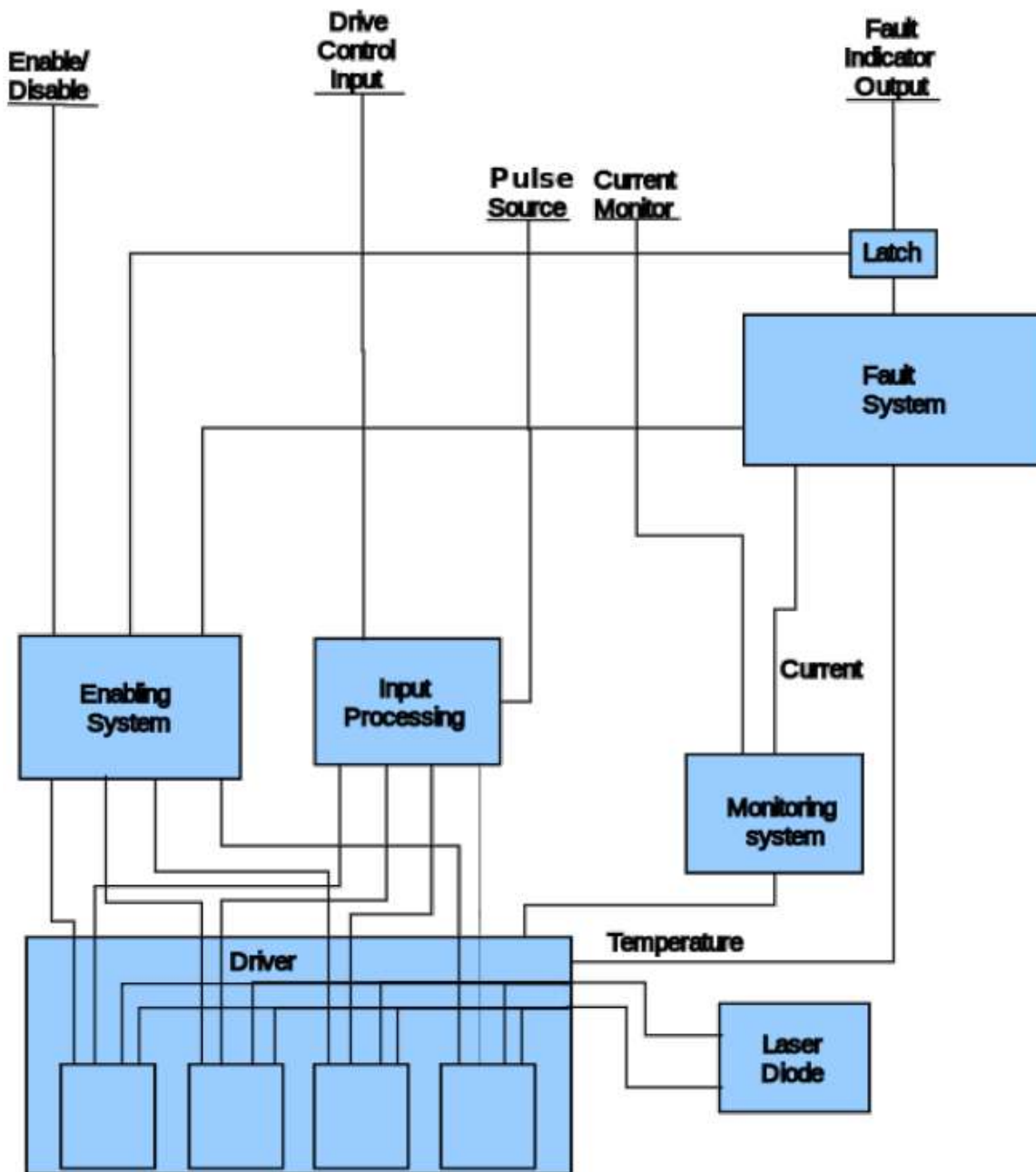


Figure 1: Block Diagram

### 1.1.3 The Driver

The driver consists of four current controlled scaled current sources connected in parallel to increase power handling capability. Each is equipped with both a fast and slow disabling circuit. The fast disabler will react to a fault in approx. 20ns and will protect the laser from all types of driver failure except for a shorted power FET or a defect in the fault system. If the slow disable is not active the fast system will cause some parts to overheat to save the laser. The slow system will disable the driver in about 1.5 $\mu$ s. The slow disable reduces the power dissipation of the entire driver including the dissipation in the fast disable system. Both systems are activated simultaneously by the enable system in response to either the user changing the state, or a driver fault signal.

### **1.1.4 The Monitor System**

The monitor system performs two main functions:

1. Provides a scaled voltage representing the laser current for use by the Fault system.
2. Generates the Current Monitor output signal.

### **1.1.5 The Fault System**

The Fault system processes two kinds of faults:

1. Current fault. Current exceeds adjustable set level.
2. Temperature fault. Power FET case temperature exceeds preset limits.

Both faults are created by simple comparators monitoring appropriate signals. They are ORed together and latched to provide the fault output. Cycling the Enable/Disable input with the fault condition corrected will reset the latch as will cycling the power.

## **2 Handling**

### **2.1 Prior to Mounting**

The driver assembly will require careful handling, after removal from its shipping plate. Leave the driver attached to the shipping plate until ready to transfer to its permanent mounting location.

Each assembly has a two-part heat sink attached. The heat sink is kept assembled by two screws. The heat sinks are held in place relative to the board strictly by the friction, adhesion, and conformation around the parts of the thermal interface material. This material can be damaged by forcing the heat sink out of position. Should this happen, the interface thermal resistance will rise, and the driver reliability will be compromised. Damage of this type can be detected by misalignment of the heat sink mounting holes which pass through the board. Should damage to the interface material occur, the best practice is to return the driver to the factory for replacement of the thermal interface material, and realignment of the heat sinks.

The heat sink body parts are made of soft copper. They are plated with nickel to increase scratch resistance. The bottom (mounting) surface of the heat sink is machined very flat and smooth. An impact with a harder object, especially along the bottom edge can deform the soft copper and cause a large increase in the mounted thermal resistance. Should this type of damage occur, the bottom heat sink part will require replacement.

Neither of these damage types can occur after the driver is mounted.

### **2.2 Mounting the Driver**

#### **2.2.1 Materials Required**

The following materials will be needed to mount the driver assembly:

1. The Driver
2. An air, water, or Thermo-electric cooled mounting surface with 0.1°C/Watt or better for

maximum rated power. Heat sink temperature at the mounting point should not exceed +40°C @ +25°C ambient.

3. Thermal mounting pad
4. 5ea. M2.5 X 0.45 X 25mm screws
5. 5ea. Washers for above
6. 10ea. Conical spring washers for above
7. 3ea. M3 X 0.5 X 6mm screws
8. 3ea. Washers for above.
9. 3ea. M3 X 0.5 X 6mm male/female standoff spacers.
10. Thread locking compound Loctite 222 or equivalent.
11. Isopropyl alcohol.
12. Lint Free wipes or towelettes.

Items 3 through 9 are supplied with the unit from the factory.

### **2.2.2 Inspection and Cleaning**

Inspect the mating surfaces of both the driver and the base. Do not continue assembly if they are not completely flat and smooth. Clean the mating surfaces of both parts with alcohol and a clean wipe. Place the mating surfaces in contact. Verify with a strong back light that parts are in intimate contact.

### **2.2.3 Install Standoffs**

Apply a drop of thread lock to the male end of the standoff. Thread into the plate and tighten.

### **2.2.4 Applying Thread Lock and Thermal Pad**

Place a drop of thread lock in each mounting hole in the plate and in the female ends of the standoffs. Wipe clean any that gets on the mating surface of the plate. Peel the plastic protective sheet from both sides of the thermal pad. Place on the plate aligned with the mounting holes.

Assemble the hardware as follows:

1. Place a 3mm washer on each 3mm screw.
2. On each 2.5mm screw, place a conical washer with the small end toward the screw head. Add a flat washer and another conical spring washer (large end of cone on flat washer, small end away from screw head as shown).

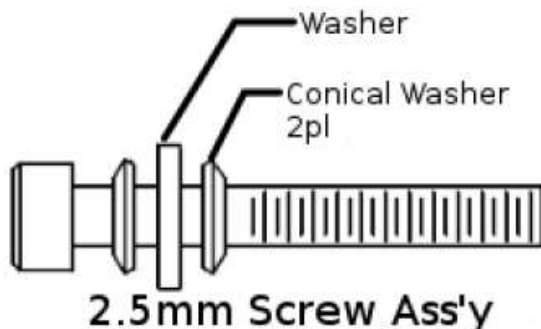


Figure 2: Screw Assembly

3. Insert the assembled 2.5mm hardware into the 5 holes illustrated [Board Figure](#).

### 2.2.5 Attach

Carefully lower the assembly so that the screws enter their appropriate mounting holes. Install and tighten the three M3 screws at the standoffs. Screw in all the 2.5mm screws to leave a small gap (<1mm) between the screw heads and the washers.

### 2.2.6 Torque

Referring to the [Board Figure](#), tighten the heat sink screws, in the sequence shown, to the torque shown in Figure 2.1: Heat Sink Screw Torque. Do Not touch the factory installed screws on the heat sink. Torque each screw to the same torque again.

Sequence	Torque
See Fig. 5 <a href="#">Board Figure</a>	30cNm

Figure 3: Heat Sink Screw Torque

The resulting interface should have a thermal resistance of <0.15°C/W as assembled. It can be reduced further (to approx. .06) by melting or allowing the phase change pad to melt. The pad must reach a temperature of 57°C to melt. This does not occur in normal use, so a separate process would be needed. Torque all the screws, including the 2 screws marked ⓧ while the phase change pad is in the liquid state.

### 2.2.7 Disassembly

Should it be necessary to remove a mounted driver, remove the board side heat sink screws first, then the remaining screws. Remember *not to disturb the factory installed screws in the heat sinks*, if the drivers are to be reused. Thoroughly clean all parts that will not be discarded. *A new thermal pad will be needed for reassembly.*

## 2.3 Mounting the Laser

### 2.3.1 Mounting

The laser should be attached to the heat sink using materials and methods prescribed by the laser manufacturer. If the driver and the laser are to share the same heat sink, be sure to make adequate allowance for the thermal load of both during cooling system design. Because of the wide variation in laser configurations and ratings, cooling design allowances are beyond the scope of this document.



### 2.3.2 Soldering

After mounting the laser, solder the pins or cable to the cathode and anode pads (See [Board Figure](#)) with a solder alloy compliant to the ROHS specification. For best performance keep the wiring as short as possible, a planar or twisted pair are recommended to keep the return current coupled as tightly as possible to the outgoing current.

## 3 Electrical Specifications and Requirements

### 3.1 Interface

#### 3.1.1 Connectors

The high current power is connected via 2 IHI B12-PCB Box Connectors, see [Board Figure](#) for polarity assignment.

The input, output signals and power for the electronics are connected via 1 - 14 pin Tyco MicroMatch Connector P/N 8-215460-4. The mate for this connector is Tyco P/N 8-215083-4. See [Board Figure](#) for pin and key location.

### 3.2 Signals

Pin	Signal
1	Current Monitor Output
2	Ground
3	Pulse Source
4	Ground
5	Drive Control Input
6	Ground
7	N/C
8	Ground
9	Enable/Disable Input
10	Ground
11	Fault Indicator Output
12	Ground
13	N/C
14	Electronics Power +10V to +14V

Figure 4: I/O Connector Pinout

#### 3.2.1 Input Power

##### Electronics Power

The driver is designed to operate from a DC current source of +10V to 14V at 100ma maximum current. This is processed on the board to operate the drive electronics.

## **Laser Power**

The load is powered through a high current supply. It is recommended that the power source ripple be less than 100mV at full current. The driver inherently produces no ripple of its own. Standard techniques for reducing the ripple applied to the circuit have been applied, but the effectiveness of these techniques will not be just a function of the driver design. It will also be a function of the host system wiring, the wiring inside the laser box, ground loops, distance to the power source, and the power source responses to sudden massive load increase. It is recommended that the power wiring be a twisted pair, be kept as short as possible and as far from the analog circuitry as possible inside the package. The board layout keeps the most sensitive areas of the board far from the power input, but shielding should be considered to prevent crosstalk between the power wires and the signal cable. The wire used for the power hook up should be at least #14 and up to #10 based on the length of the run. The maximum voltage that can be applied to this input is +28VDC.

### **3.2.2 Current Monitor Output**

The current monitor output is the direct output of a rail to rail operational amplifier. It is scaled to reach 4.0V at 20A. There is a 50 $\Omega$  resistor in series to damp the line inductance and isolate the op amp output from any capacitance added to the line. This is a common practice when using an A/D converter as the load. Despite the 50 $\Omega$  source impedance, no more than 10ma should be drawn from this output.

### **3.2.3 Pulse Source**

This is a TTL voltage level compatible input. The input impedance is 1k $\Omega$  to ground. It will tolerate input voltages from 0V to 5.5V. When the input is LOW, only bias current flows in the laser. When HIGH, the programmed drive control current will flow in the laser, in addition to the bias current. Should this input become open circuited, the input will default to LOW.

### **3.2.4 Drive Control Input**

This input is an analog input with the range of 0.0V to 5.0V. The input impedance is 1k $\Omega$ . The input will tolerate voltages up 5.5V. The voltage at this input will determine the laser current when the Pulse Source transitions from LOW to HIGH. It is scaled at 4A/V. If this input becomes open circuited, it will default to 0V.

### **3.2.5 Enable/Disable Input**

This is a TTL voltage level compatible input. The input impedance is 11k $\Omega$  to ground, when functional. When faulted the impedance is 1k $\Omega$ . The input will tolerate 0.0V to 5.0V. When this signal is HIGH the laser will be driven with either the bias current or the bias current plus the programmed drive current. When LOW there will be no laser current regardless of the state of any other input. If this input is left open it will default LOW.

### **3.2.6 Fault Indicator Output**

This TTL level compatible latched output is capable of sourcing or sinking up to 50ma. However, it is recommended for best reliability to limit the source and sink currents to 10ma max. This output is not short circuit safe to either rail. The output will be HIGH if either of the two fault types has gone TRUE since the last reset or power up. The latch can be reset by setting Enable/Disable LOW. Note that, if the fault has not gone away (applies mostly to temperature due to its slow response), the output may oscillate while the Enable/Disable is LOW. This response is typical of a set/reset latch when both the set

and reset are active simultaneously.

### 3.2.7 Ground

The grounds in the signal connector should be used to reference all analog signals. Use of the power ground for reference will result in coupling the drops due to current drain to the input of the device. This will at least cause errors in the driver current level. At worst, the driver may self-oscillate from the feedback.

## 3.3 Controls

### 3.3.1 Current Limit Adjustment Pot

The current limit adjustment pot is used to set the current level at which the driver will shut down and issue a current fault. It has an adjustment range of from near zero to slightly higher than 21A. The factory setting is to fault between 20A and 21A.

For the location of the pot see [Board Figure](#).

For the adjustment procedure see [Setting the Current Limit Trip Point](#).

### 3.3.2 Laser Bias Adjustment Pot

For the best pulse response, the laser needs to be biased with a small current. Each of the four drivers needs to have some current in it. Failure to bias the drivers positive will result in the op amps being saturated negative. The slow recovery from saturation when commanded for current will cause a long delay followed by discrete steps on the rising edge. Consequently, negative or zero bias is only useful for CW applications where the shape of the rising edge is unimportant. The factory setting for the bias is 125mA nominal, split between the four drivers.

For the location of the pot see [Board Figure](#).

Should readjustment of the bias level be desired, or a different setting is needed, see [Setting the Laser Bias](#).

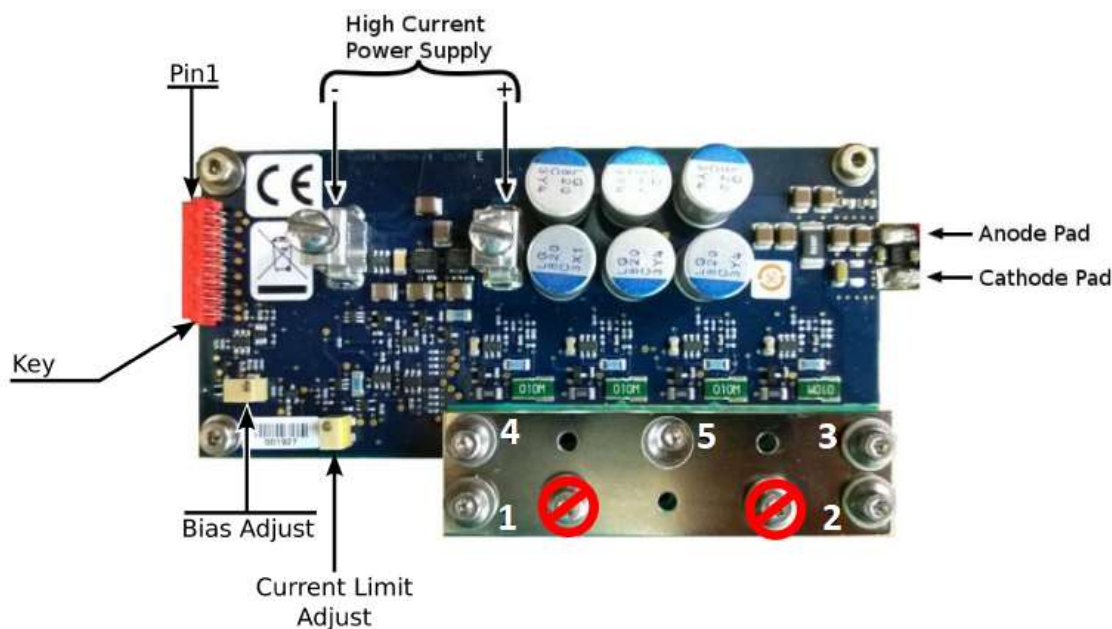


Figure 5: Board Figure

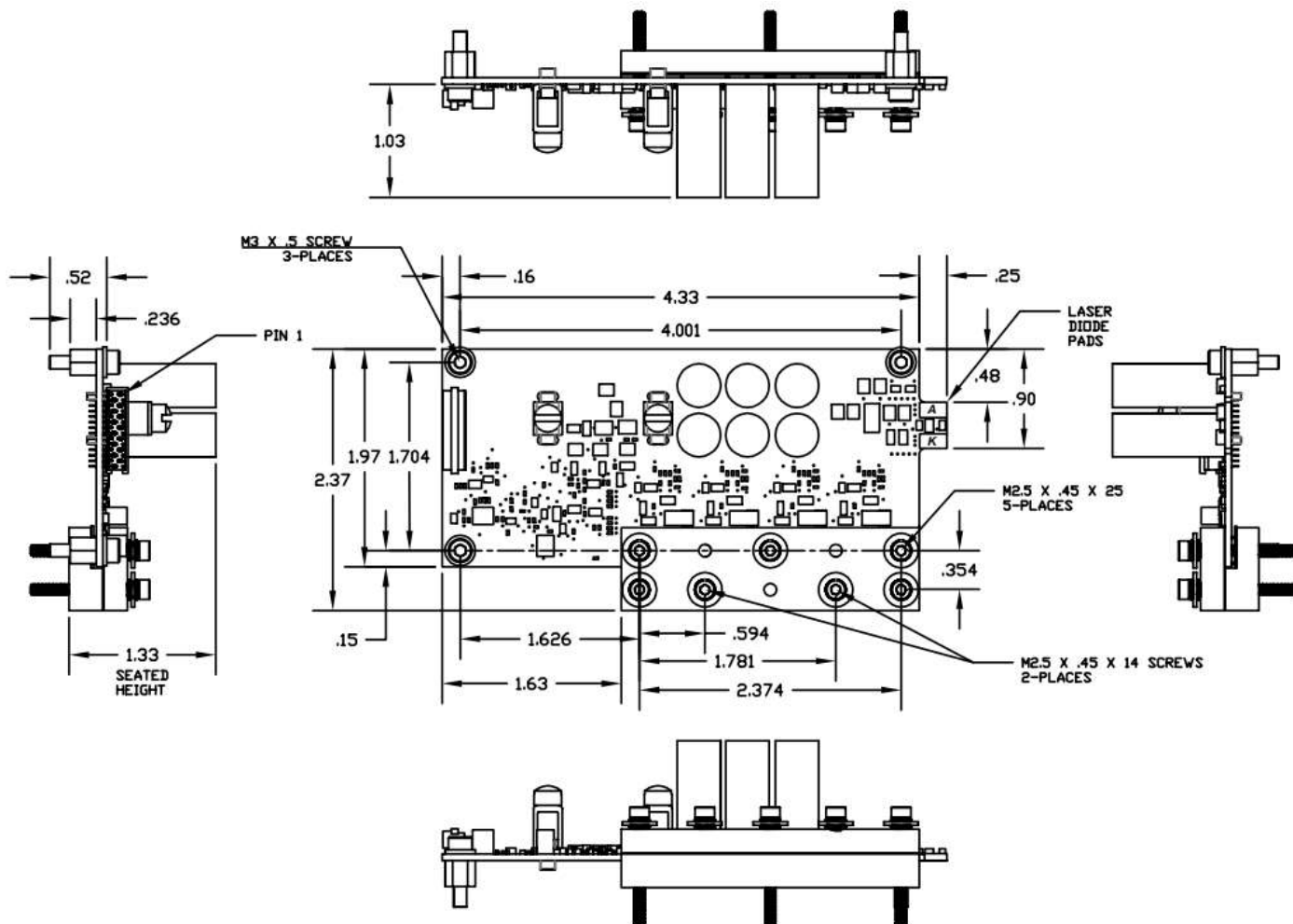


Figure 6: Mechanical Outline

## 4 Using the Driver

**WARNING:** The optical output of this laser system is of such a power to represent a significant hazard. It has the potential to produce severe skin and eye damage. **DO NOT** enable the driver unless the optical output is under control (somewhere where the optical output will not damage personnel or equipment). Make certain all required safety devices are employed and functional. The responsibility for safe operation lies with the user.

### 4.1 Matching the Driver to the Application

The first item of information needed is the laser voltage drop at the planned maximum current. The laser power supply should be 1-5V above the laser compliance voltage.

The low end of the range gives better efficiency in the driver and allows minimizing the power supply requirements. Use this end of the range if rise times  $>1\mu\text{s}$  are not a problem.


The high end of the range will give the shortest rise times. How high the voltage needs to be for best performance is a function of the wiring length and any inductance reducing techniques which are used in the laser hook up. Avoid using voltages above 6V over the laser drop, even with reduced currents. The FETs used in this design are designed for switch mode operation. We are using them in an analog

application. The FETs are composed of thousands of tiny FETs, each with its own threshold and gain. This causes the current to split unevenly, resulting in hot spots. The parts have been heavily de-rated to maintain reliable operation. Decreasing the current will reduce the number of FETs sharing the current. Increasing the voltage at this point will increase the hot spot temperature reducing reliability. The driver should not be used to drive a linear load, such as a resistor, or heating element. The load must be exponential so that the voltage increases rapidly at small currents rapidly reducing the voltage across the driver.

Determine the maximum current to be applied, and the duty cycle for pulsed applications. Arbitrary waveforms should be treated as QCW (duty cycle =1). Use the following equation to determine the maximum power dissipation of the application:

$$P = \text{duty cycle} * (\text{LaserSupply} - \text{LaserDrop}) * \text{PeakCurrent}$$

The thermal resistance from the FET junction to the mounting surface is approximately 0.525 deg./Watt, including the thermal pad. Use this figure, the power, and the ambient conditions to determine the required heat sink and cooling method. Use of some safety factor would be wise to cover aging and cooling system efficiency factors (such as clogging of air filter, low water level, etc).

If the power is > 100W, the assembly will benefit from preconditioning. Heat the assembly to 70-80°C. Re-torque all of the screws to their final values including the two screws with the  sign in the illustration [Board Figure](#) while the assembly is still hot. Two of the insulators are phase change pads. Performing this preconditioning will melt the pads and allow the screw pressure to force out some of the material and at the same time increase the wetting to the heat sink. The result will be a reduction in the junction temperature of up to 15°C.

## 4.2 Power on

It is best to keep the laser power off until after the driver power has stabilized. Considerable effort has been expended to avoid transient light output at turn on and off under any circumstance where light would not be emitted during steady state operation. It is however recommended that the Enable/Disable and Drive Control inputs be kept LOW at turn on. Allow a full second for the on-board power supplies to start up and stabilize before commanding action.

## 4.3 Enable

Raise the Enable/Disable input to the HIGH state. The driver will require 100ns to become fully operational after the Enable/Disable signal rises. There are no restrictions on any other signal states. The driver can be enabled at any time.

## 4.4 Disable

Lower the Enable/Disable input to the LOW state. The driver will require 170ns to completely disable. There are no restrictions on any other signal states. The driver can be disabled at any time.

## 4.5 QCW Mode

Normally this would be accomplished by setting a small bias current, holding Pulse Input high, and setting the desired CW current with the Drive Control.

### 4.5.1 Drive Control Setting

Set the Drive Control input voltage to the desired current according to the following formula:

$$V = A / 4.0$$

where V is the Drive Control input voltage and A is the desired current, not including the bias current.

The laser current will require a maximum of 1 $\mu$ S to respond to a new value.

Note: This current will only flow in the laser when the Pulse Input is HIGH. The laser current will equal the programmed current plus the bias current.

## 4.6 Pulsed Operation

Pulsed operation can be accomplished in two ways. Both will have similar pulse characteristics.

### 4.6.1 Modulation with Drive Control

In this mode the Pulse Input is held HIGH. The Drive Control input is pulsed from 0V to (desired\_HIGH\_current-bias\_current)/4 volts. The rise and fall time will be the slower of 1 $\mu$ s or the rise time of the source.

### 4.6.2 Modulation with the Pulse Source

In this mode the HIGH current level is set on the Drive Control input (desired\_HIGH\_current - bias\_current)/4 volts, and the Pulse Source is switched to form the pulses. In this mode the rise and fall times will be 1 $\mu$ S maximum unaffected by the Pulse Source signal characteristics.

## 4.7 Arbitrary Waveform Creation

To create an arbitrary waveform, set the bias current to a low level (100ma or so). Set the Pulse Source HIGH. Rapidly set the Drive Control incrementally or use a continuously varying analog signal to control the envelope of the waveform. Note: if using digital control, waveform slopes may display a "stair step" effect if the resolution and or speed are not sufficient. The current will step from point to point in less than 1 $\mu$ S.

## 4.8 Mixed Modes

The driver places no restrictions on the manipulation of the inputs. Any signal can be changed at any time, and the unit will respond within the speed and amplitude constraints of each signal. Signals containing both amplitude and pulse position, pulse width, frequency, or phase modulation can be created.

## 4.9 Auxiliary Signals

There are two auxiliary outputs on the driver to monitor the status of the device. Use of these signals is discretionary. A description of each follows.

### 4.9.1 The Current Monitor Output

For electrical specifications for this signal see [Current Monitor Output](#). This output is a direct representation of the current in the laser. The signal responds to all signals which affect laser current.

The delay in response is about 50ns. With this large phase delay, it would be difficult to use the signal to produce an analog closed loop current control, so this is not recommended.

## 4.9.2 The Fault Output

Latching of the fault output can result from two causes. The fault system's primary function is to protect the laser first and then the driver.

A fault generally results from one of the following causes:

1. User error (current set too high, failure to turn on cooling system, incorrect setting of current limit, or wiring problem with laser, and/or driver signals). This will usually occur during system development or testing.
2. Component failure, or drift in settings or values(aging). Generally occurs after long field life.
3. Cooling system failure. Base plate temperature must be held below 40°C.
4. Unit overheats. Should not happen if the unit is properly mounted, the cooling system is properly designed/specified and the driver dissipation is  $\leq 130W$ . See [2.2](#)
5. Noise. False fault from system (including host) noise.

Except for item 5 above, a fault means there is something wrong. There is only a single fault output, so it cannot differentiate the source. In general, current faults can be reset immediately. If the current is set to 0, and the fault repeats immediately, then it will usually be a thermal fault. Wait 1 minute. Try to reset again. If unit resets, it was thermal and needed to cool down some. If not, it is probably a component failure. If it resets immediately, set the current to a low value (1-2A). If it faults again immediately, it is a defective component. This is the extent of troubleshooting which can be done without test equipment. If modulating the drive current input, overshoot on the input signal can cause a current fault.

Repeated faults over a long period can be the result of component or setting drift, or a marginal cooling situation (blocked air filter, clogged cooling fins, etc.). It is best to find and correct the problem rather than to repeatedly reset.

## 4.9.3 Resetting a Fault

To reset the fault set the Enable/Disable input to LOW (Disabled). If the fault condition has cleared, normal operation should resume when the driver is re-enabled.

## 4.10 Setting the Current Limit Trip Point

### 4.10.1 Factory Setting

The trip point is set at the factory to between 20A and 21A. If this is not satisfactory or has been disturbed proceed with the process described below.

### 4.10.2 Adjustment Procedure

1. Set then Current Limit adjustment pot fully CCW (See [Board Figure](#)).
2. Set up the driver for pulsed output (See [Pulsed Operation](#)) with the HIGH level equal to the desired trip point.
3. Monitor one of these signals with scope or meter: Current Monitor or Fault Output.

4. SLOWLY adjust the pot CW. Stop immediately when one of the following happens: Current Monitor output drops, Fault output goes HIGH.
5. Lower the current by 100ma. Tap pot several times to settle the wiper.
6. Reset fault (See [Resetting a Fault](#)).
7. Incrementally increase current. Verify the setting where the driver faults. If current is satisfactory, done. If not repeat process from step 2.

It is not uncommon for a pot to stress relieve after adjustment. This is the reason for the tapping in the above procedure. As the adjustment direction is CW the stress relief will usually move the wiper CCW, or to a higher current setting. If this is problematic, pre-adjust the initial current to a slightly lower value. Then after de-stressing the adjustment will be closer to the desired value.

## 4.11 Setting the Laser Bias

### 4.11.1 Duplicating the factory setting

If no bias is desired, set bias pot fully counterclockwise. For setting the bias to minimum for pulse operation, use the procedure below. To set to a fixed current (factory set is 125mA), use the procedure from the next subsection.

1. Set the unit up for pulsed operation, with a 100 $\mu$ s pulse width.
2. Rotate the bias pot fully counterclockwise.
3. Observe the driver output on an oscilloscope connected to the current monitor output.
4. The pulse on the scope should have several stair steps on the leading edge.
5. Rotate the pot clockwise until all the stair steps have disappeared.
6. Tap the pot several times to stress relieve. If none of the steps return the adjustment is finished.

### 4.11.2 Setting to a Fixed Current

1. Set up unit for CW operation. Enable, but keep the pulse input at the LOW level.
2. Rotate the bias pot fully counterclockwise.
3. Observe the driver output with a DC voltmeter connected to the current monitor output.
4. Read the voltage, be sure to note sign.
5. Calculate the required reading from the following equation:

$$0.2 * \text{Current in Amps} + \text{Voltage from Step 4}$$

6. Adjust the pot clockwise to obtain the calculated value on the meter.
7. Tap the pot several times to stress relieve. If reading on meter is satisfactory the adjustment is finished.



It is not uncommon for a pot to stress relieve after adjustment. This is the reason for the tapping in the above procedures. As the adjustment direction is CW the stress relief will usually move the wiper CCW, or to a lower bias current setting. If this is problematic, pre-adjust the initial current to a slightly higher value. Then after de-stressing the adjustment will be closer to the desired value.

## 5 Specifications

PARAMETER	785A			Units
	Min.	Typical	Max.	
<b>INPUT</b>				
Power (Driver)	+10.0	+12.0	+14.0	VDC
Current (Driver)	-	50	100	mA
Power (Laser)	+3.0	-	+28.0	VDC
Current (Laser)	-	-	20	A
Control Voltage (Scaling = 4A/V ± 5%)	0	-	5	V
Pulse Source (TTL)	2.2	-	5	V
Enable (TTL)	2.2	-	5	V
<b>OUTPUT</b>				
Current	0	-	20	A
Compliance Voltage	1.5	-	26	V
Pulsewidth	2.0	-	CW	µs
Duty Cycle	0	-	100	%
Modulation Bandwidth	-	-	600	kHz
Risetime at 20A (10% to 90%)	400	-	1000	ns
Ripple	-	~0	<1%	A <sub>RMS</sub>
Noise	-	0.9%	2%	%
Pulse Overshoot at 20A	-	2%	4%	%

### Absolute Maximum Ratings

PARAMETER	Min.	Max.	Units
<b>INPUT</b>			
Power (Driver)	9	16	VDC
Power (Laser)	-	28	VDC
<b>OUTPUT</b>			
Power Dissipation $P = (\text{DutyCycle}) \times (\text{LaserSupply} - \text{LaserDrop}) \times (\text{PeakCurrent})$	-	130	W
<b>TEMPERATURE</b>			
Operating:	0	+50	°C
Storage:	-20	+70	°C
Humidity:		< 95% Non-Condensing	