

A0-Diode Pumped Chassis

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Abstract

This report documents the production of the first Diode pumped chassis for use in A0 laser laboratory. It will recount the tests conducted, the results, and the issues to be considered when producing the next system for future use.

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Introduction

This report documents the installation and setup of the *Diode Pumped Chassis* that will replace the current diode source inside A0 laser laboratory. The configuration in A0 laser lab currently uses two diode drivers and two power supplies, however one diode driver should be sufficient to power up to 15 diodes. The diode pumped chassis will be used as the pump laser for two-pass and multi-pass diode pumped amplifiers. The configuration is shown in Figure [1].

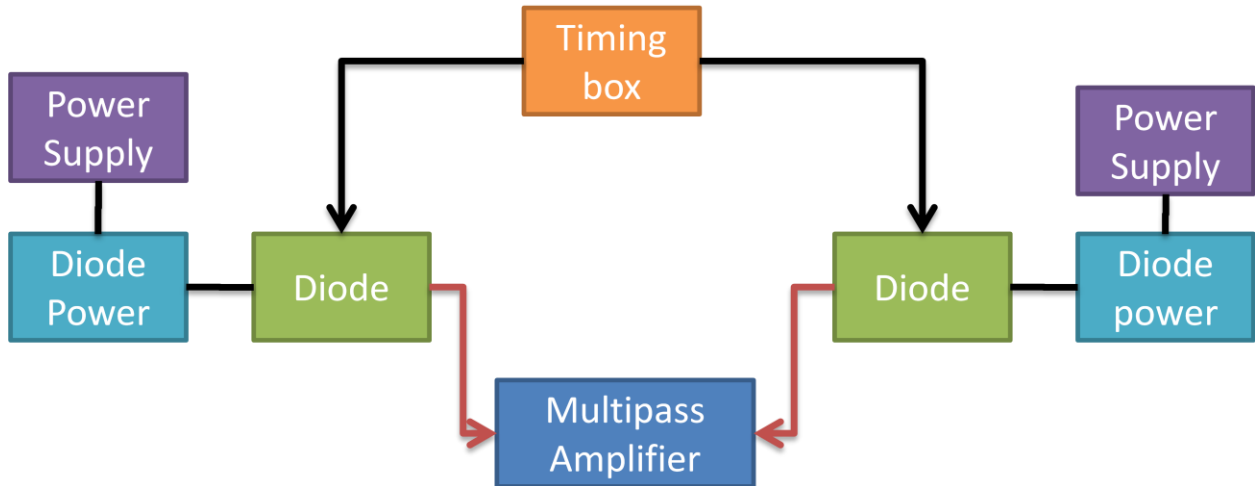


Figure [2]: Animation of current diode pump for multi-pass amplifier.

The multi-pass amplifier is used to amplify the seed lasers pulses to tens of μJ , and the two-pass will further amplify the signal to hundreds of μJ as it is directed towards the CsTe photocathode.

The primary difference between the current and new system is the use of one diode driver to power two separate diodes in series. In addition, new parts were also introduced into the system including:

- 2 X 800 μm , 100 W, QCW Conduction cooled single bar fiber coupled modules
- 1 X High Power CW or Pulsed Laser diode driver
- 1 X DLM-600W Series M51A Option Isolated Analog Power supply

The expected performance specs of the system are an output of 100 W, a pulse width of 1 ms, and a 5 Hz repetition rate. The parts are installed into a chassis which can be mounted on any standard rack unit.

Design

Parts & Important Components

Top view.

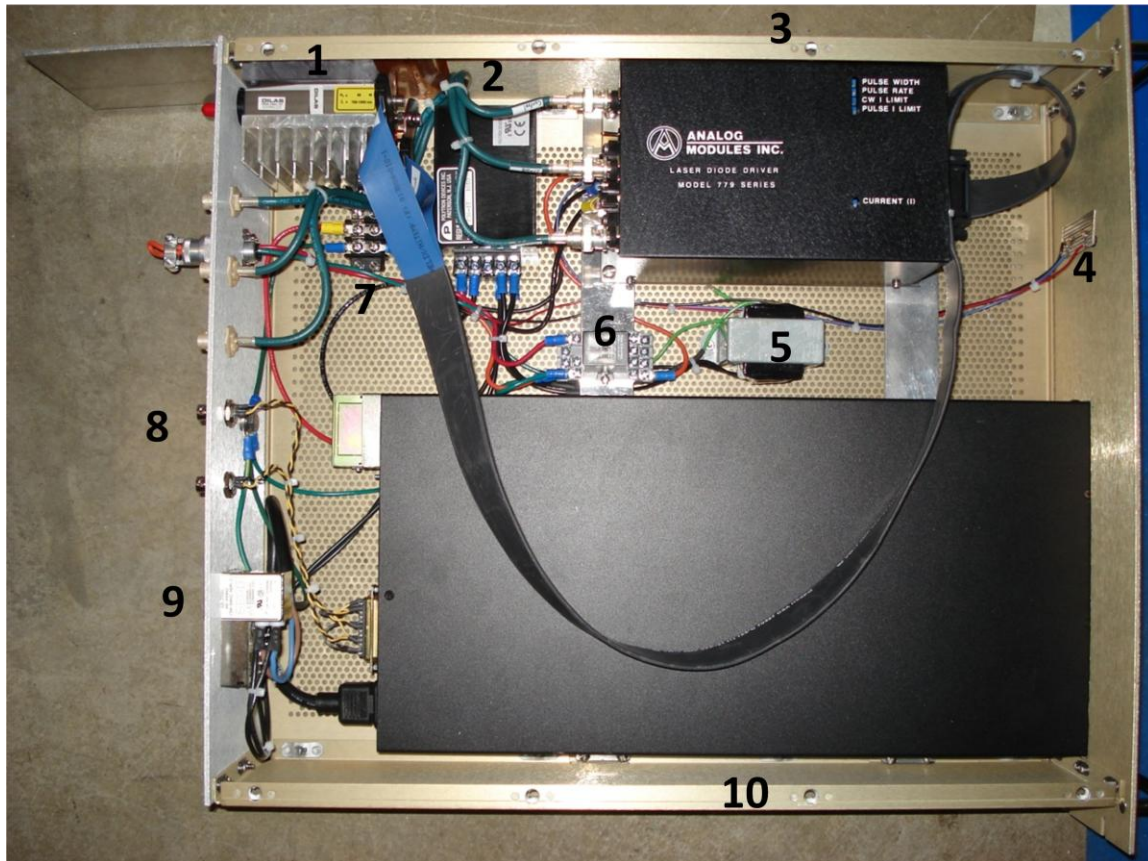


Figure [3]: Top view.

1. Diodes

Two 800 μm , 100W, DCW Conduction Cooled Single Bar Fiber coupled Modules mounted beside an aluminum heat sink. These diodes are paired in series and electrically isolated from the heat sink, to disallow the chance of completely bypassing one or the other diode through the heat sink to chassis ground.

- 2. AC Power Supply
- 3. Diode driver

High power CW or Pulsed Laser Diode Driver that outputs 20 Amps CW or 120 Amps pulsed, and provides a pulse width to 1.0 ms¹.

¹ <http://www.analogmodules.com/admincenter/datasheets/779a.pdf>



Figure [4]: High power CW or Pulsed Laser Diode Driver ²

4. LED
5. Relay Switch
6. 120V to 24V Transformer
7. Terminal Block
8. Signals
9. AC in
10. Bulk DC power supply

DLM-600W Series M51A Option Isolated Analog Power supply, which provides a remote programmable option through its DB25 connector with the following setup.

Sorenson DLM 600W Bulk Supply Back Panel INTFC Switches

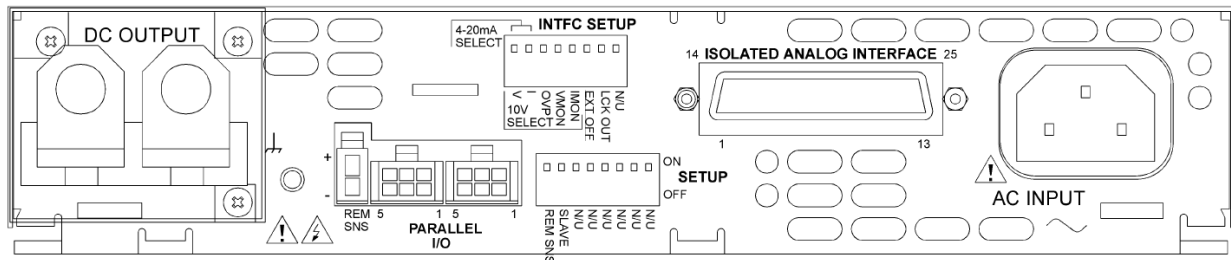


Figure [5]³: Back panel

The DLM 600W power supply can be set to many different settings via the INTFC switches located on the back panel of DLM600W unit. Each of the 8 switches corresponds to a different function. The primary modes being utilized in A0 include: 0-10 V mode, low-logic external off control of the outputs, voltage and current monitor. This is achieved by the positioning of the switches. Even though the primary controls are the 0-10 V (position 1), voltage monitoring (position 4), and on/off control (position 6), the complete list of functions is below:

² <http://www.mjinc.com/data/file/productimgs/1299305075552189922212.jpg>

³ Back Panel. Figure 2-1 p. 2-3, Sorensen DLM 600W Series Power Supplies: M51A Option Isolated Analog

Table [1]⁴: INTFC Switches

Switch Position	Function	OFF (Down) Position	ON (Up) Position
1	V, 10V or 4-20mA Select	0-5VDC	0-10VDC or 4-20mA ⁵
2	I, 10V or 4-20mA Select	0-5VDC	0-10VDC or 4-20mA
3	OVP, 10V Select	0-5VDC	0-10VDC
4	VMON, 10V Select	0-5VDC or 4-20mA	0-10VDC ⁶
5	IMON, 10V Select	0-5VDC or 4-20mA	0-10VDC
6	EXT-OFF, Active-Low Select	Active-High Logic Level	Active-Low Logic Level ⁷
7	LCK-OUT	Enable Front Panel Controls	Lockout Front Panel
8	Not Used	—	—

⁴ Table 2-1 p.2-1, Sorensen DLM 600W Series Power Supplies: M51A Option Isolated Analog Programming Manual

⁵ Setting used in A0 Laser lab

⁶ Setting used in A0 Laser lab

⁷ Setting used in A0 Laser lab

DB25 Pin Configuration

Another feature that offers more control of the DLM600W bulk supply is the remote control option, which will allow for the manipulation of the diodes without the use of the front panel. This is achieved through the isolated analog interface that is programmed through a DB25 sub with the following pins configurations:

Table [2]⁸: Pin designations

Pin	Function
1	ANALOG-CONTROL input
2	Return for 0-5/10V monitor outputs and EXTERNAL-OFF
3	OVP programming input
4	Voltage monitor output, 4-20mA
5	VOLTAGE-MODE status output
6	Return for 4-20mA monitor outputs, Auxiliary 5VDC, and digital I/O
7	Current monitor output, 0-5/10V
8	1.25VDC output for 4-20mA voltage programming signal
9	Voltage programming input
10	Current programming input
11	1.25VDC output for 4-20mA current programming signal
12	Return for 0-5/10V or resistance programming signals
13	Return for 4-20mA current programming signal
14	EXTERNAL-OFF input
15	Auxiliary 5VDC output (+)
16	OVP resistance programming output, 1mA source
17	OVP status output
18	FAULT status output
19	Voltage monitor output, 0-5/10V
20	1.25V input for 4-20mA voltage programming signal
21	Voltage resistance programming output, 1mA source
22	Current resistance programming output, 1mA source
23	1.25V input for 4-20mA current programming signal
24	Current monitor output, 4-20mA
25	Return for 4-20mA voltage programming

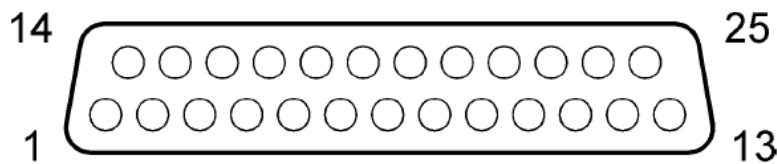


Figure [6]⁹: DB25 connector

⁸ Table 2-2 p. 2-4, Sorensen DLM 600W Series Power Supplies: M51A Option Isolated Analog Programming Manual

⁹ Figure 4-2, p. 4-3, Sorensen DLM 600W Series Power Supplies: Operation Manual

Pin map for Voltage control (0-10V) to DB25

Each pin on the DB25 Isolated Analog Interface has a designation, for its current usage. Pins #15, #2, and #12 are the absolute reference pins tied to positive or ground, as shown in Table [3].

Table [4]: Positive & Ground Pins

Positive pin	#15
Negative pin (GND)	#2, #12

The other pins are used to control the features enabled by the system when in remote control mode. These features are also available in manual mode via the front panel. The pin connections and designation are in Table [5].

Table [5]: Pin connections

Control	Positive pin	Negative (return)
Variable voltage (IRM)	#9	#12
Voltage monitor	#19	#2
Interlock	#14	#2
Remote Operation Enable	#1	-

Front view.



Figure [7]: Front panel view.

- A. Power
- B. OVP preview in display
- C. LED indicators
- D. Local/Remote switch: keep in remote mode.
- E. Over voltage protection (OVP) preview
- F. EXT-OFF control
- G. Current control
- H. Voltage control
- I. Displays

Back view.

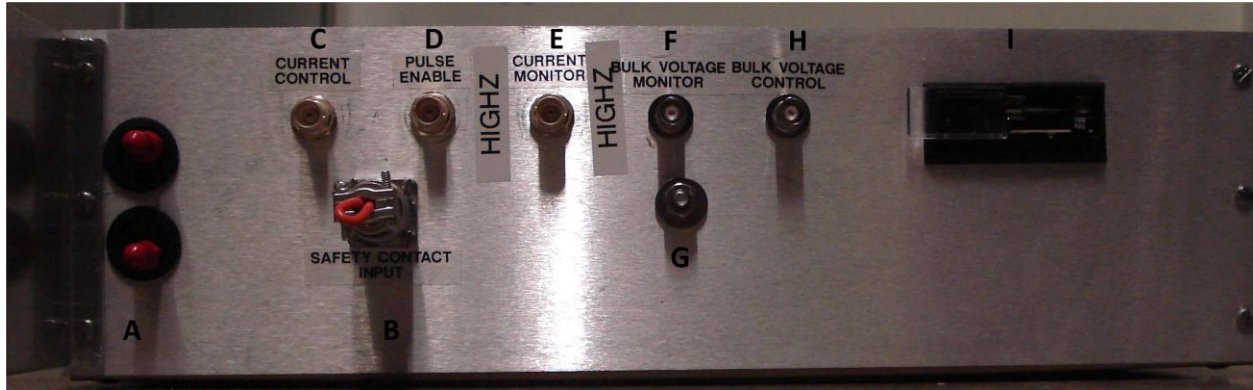


Figure [8]: Back panel view

- A. Diode outputs
- B. Safety contacts input
- C. Current control
- D. Pulse Enable (High Z)
- E. Current monitor (High Z)
- F. Bulk voltage monitor (High Z)
- G. Chassis ground
- H. Bulk voltage control
- I. Fuse

It is important that designated parts of the back panel be configured with high impedance where denoted. A circuit diagram is available in the appendix.

Considerations

Mounting the Diodes

When the diodes were first powered, light was only emitted from the second diode. The voltage across the two diodes revealed that the entire voltage was across the second diode, so the main reasons for this issue could be that the first diode was malfunctioning, or the diodes were not truly in series. Therefore the diodes were tested to guarantee that they were not broken. To test this, the diodes were switched in order to see if they behaved in the same manner. Since the problem remained only with the first diode in the series then the diodes were in fact functioning because the problem did not travel with the diode.

The resistance across the diodes was measured and since there was no resistance, then there was no current. The only other component that connected the two diodes besides the copper connection was the heat sink. The aluminum heat sink provided a path of least resistance around the first diode to the second diode, so only after the heat sink was split into two separate pieces, and electrically isolated from chassis ground and the other diode did the diodes emit the same power.

Heat Dissipated by the Diode Driver

Another important aspect to check is the amount of heat dissipated by the diode driver. Based on the desired usage, a forward bias of 2.5 V per diode, a maximum driving current of 120 A, the duty cycle of 1

ms over a time span of 200 ms then the amount of heat generated is 3 W. Based on the specification sheet provided by Analog Modules, Inc., they recommend a heat sink be installed for any amount greater than 20 W¹⁰. Therefore a heat sink was not necessary for this application.

Tests & Results

After setup, several tests were run on the unit to determine outputs in comparison to the specification sheets. The DLM600W was tested independently to verify the given properties. This unit was connected to a DC voltage via its programmable control option, the isolated analog interface DB25 connector. An important consideration for this test is that the remote operation mode is initiated when a voltage of between 3-15 VDC is connected to Pin 1 of the DB25 connector. Once this test was completed, the next step required the creation of a remote control program, which was completed in Matlab.

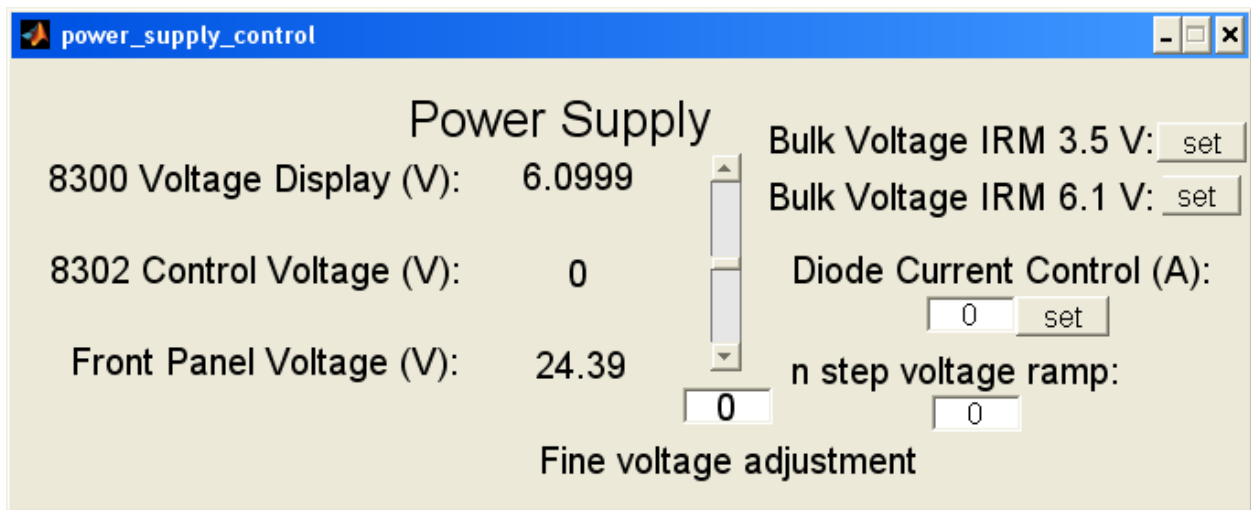


Figure [9]: Control GUI.

The program created in Matlab would communicate the desired voltage to the internet rack monitor (IRM¹¹), which will send the appropriate voltage out to the DC bulk supply unit to power the laser diode driver to manage the current to the diodes. Therefore, it was necessary to define the voltage-current plot by use of the chassis voltage and current monitoring ports.

¹⁰ http://www.analogmodules.com/admincenter/datasheets/779a_an.pdf

¹¹ http://www-inteng.fnal.gov/Integrated_Eng/irm/

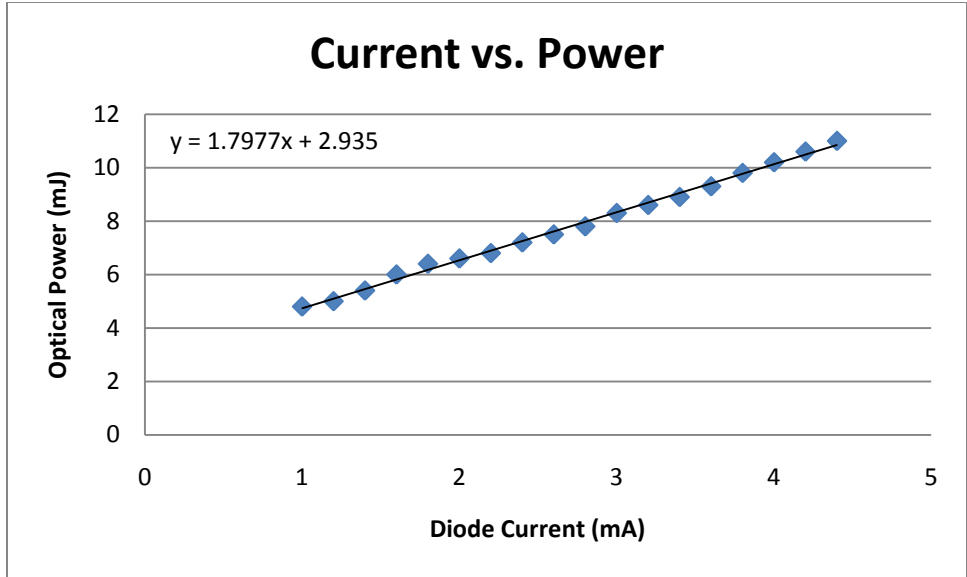


Figure [10]: Current vs. Power plot

The diode current vs. optical power was linearly fitted to the following equation:

$$\text{diode current (A)} = 1.7977 \times \text{diode current control voltage} + 2.935 \text{ (V)} \quad (1)$$

From here, the program could be used to set the diode current to a desired value. Furthermore, this program could perform fine adjustments on the voltage to reduce oscillations that appear as a result of poor coarse adjustments.

The output power of both diodes was also tested, and it was determined that the deviation between the diodes was minimal.

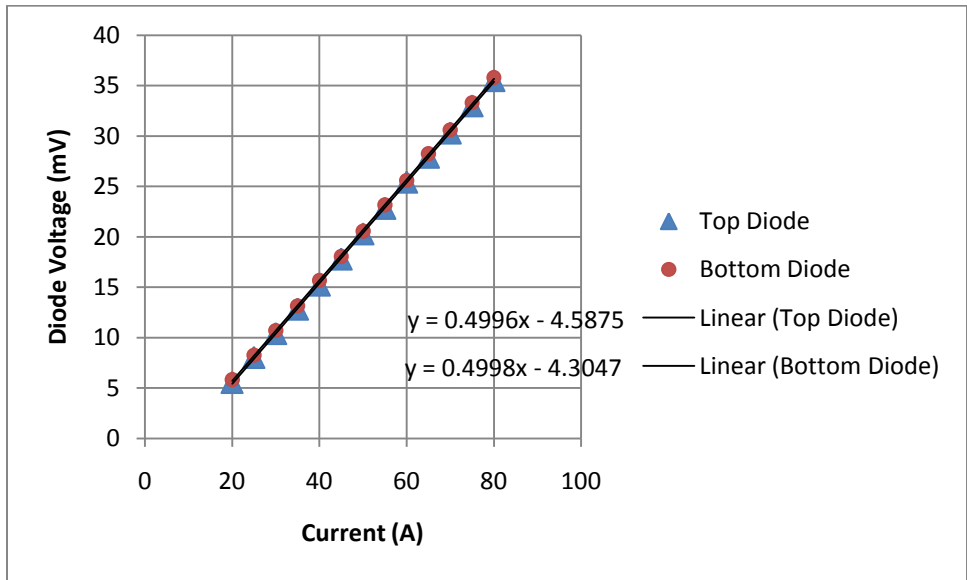


Figure [11]: Plot diode power results

Unfortunately, because the diode driver used may not support a 1 ms pulse width with the plotted current and control voltage combination, the current and voltage needs to be adjustable by the fine voltage adjustment provided in the program. When the voltage is too low, the current outputted by the diode

driver for each pulse does not produce a flat top on an oscilloscope. The signal starts to decline as the time increases towards the trigger. Another undesirable feature produced by the diode driver are the oscillations at the beginning of the signal. Sometimes it is difficult to remove the oscillations from the signals to create a complete flat top. Therefore as a first step in addressing these problems, the stable voltage for a flat top current was recorded against current for a 1 ms pulse.

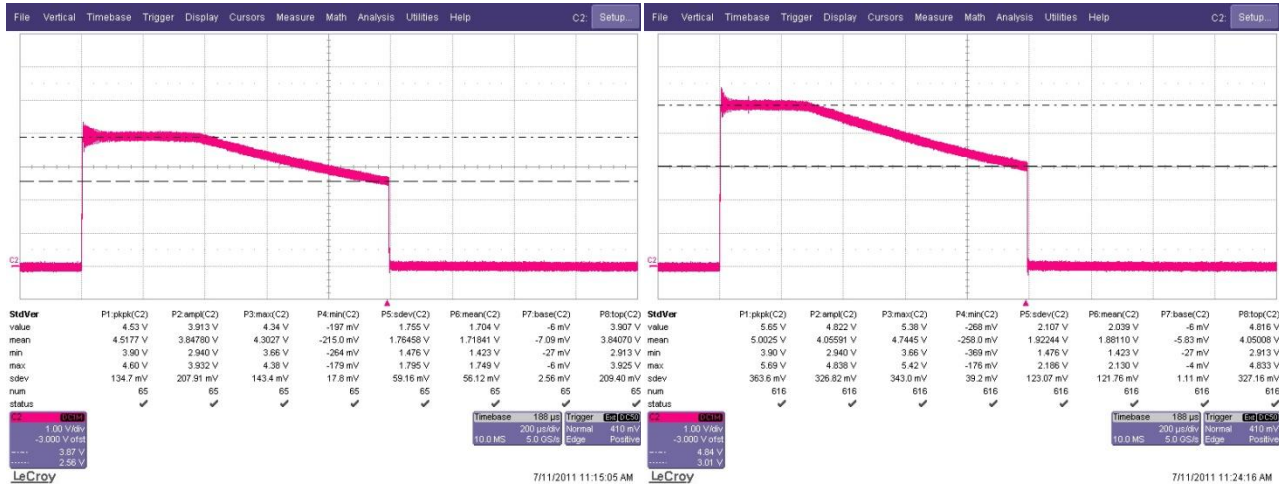


Figure [12]: Drooping current trace 80 A (right) and 100 A (left).

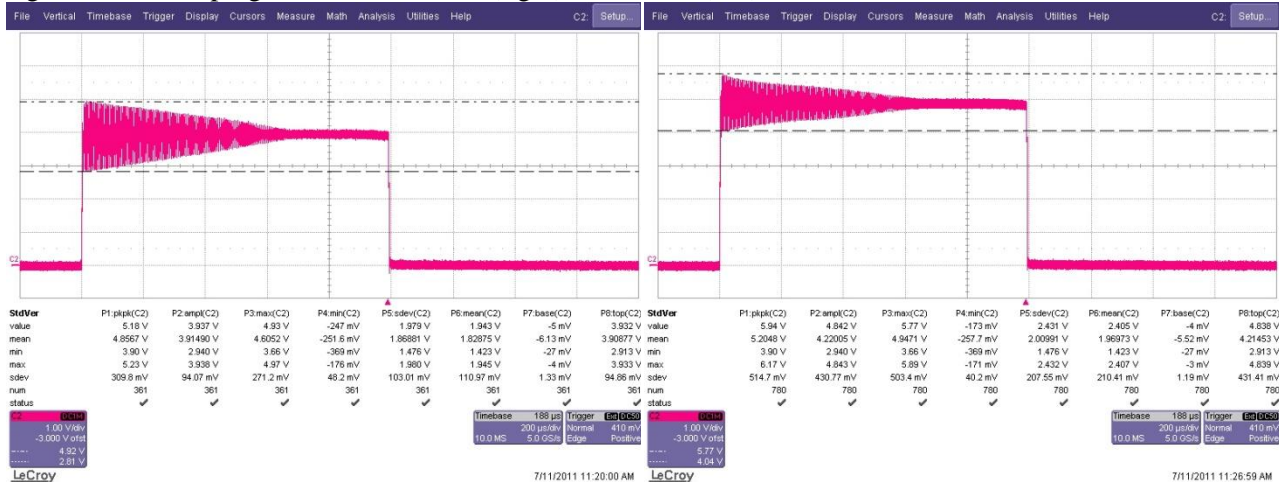


Figure [13]: Oscillating, flat top current traces. At 80 A (right) and 100 A (left).

These oscillations visible in the oscilloscope trace increase as the voltage increases, but the voltage needs to be increased to retain a flat top. This is a property most diode drivers in that when they are overdriven, they produce oscillations in the beginning of the signal. In this case, the oscillation can grow to consume the whole pulse as the voltage increases. Unfortunately, the appropriate voltages required to drive the 1 ms pulses as provided by the manufacturers are beyond the voltages that have produced oscillations in the signal.

Table [6]: Suggested voltages for diode currents.¹²

Diode current (A)	Operating voltage (V)
60	14 V
80	17 V
100	20 V

From observation, the oscillation appeared to continually increase with the voltage, so there was great hesitation to test these voltages. A 150000 μF , 63 V, 19.8 A aluminum electrolytic capacitor was suggested to be placed in parallel with the DC drive input. This addition, will be use to account for the decreasing current and the capacitors should also attenuate oscillations at the beginning of the signal.

The first test was to watch the current monitor with a 0.05 Ω , 20 W shunt resistor in place of the diodes. There was a possibility that the shunt resistor would not draw enough current because of the high impedance it could have over a 1 ms pulse of 100 W. The result was that there is in fact a threshold voltage for the diode driver and after this voltage was passed the oscillations would disappear.

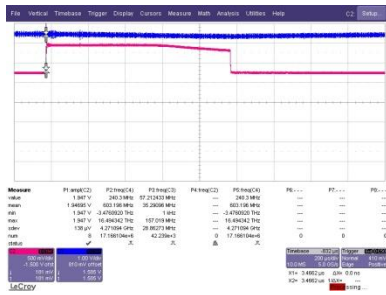


Figure [14]: Droop at diode current of 40 A and analog control voltage of 1.63 V.

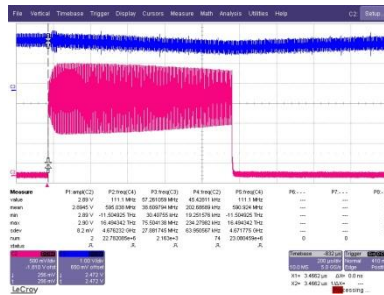


Figure [15]: Oscillations at 40 A and a analog control voltage of 2.5 V

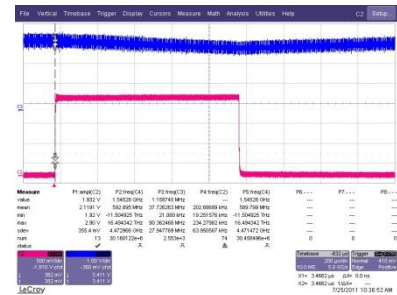


Figure [16]: Flat 40 A and a control voltage of 3.5V.

¹² Voltage suggestion from Analog Modules

Between 3.5 V and 24.2 V control voltage, the current retains a flat top, therefore the operating voltage will remain between these limits.

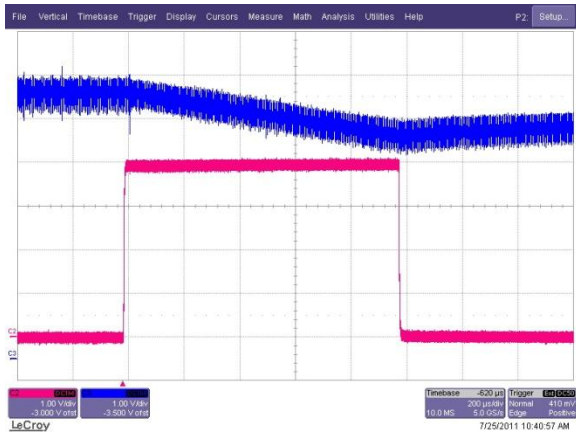


Figure [17]: 80 A flat top at 6.1V control voltage.

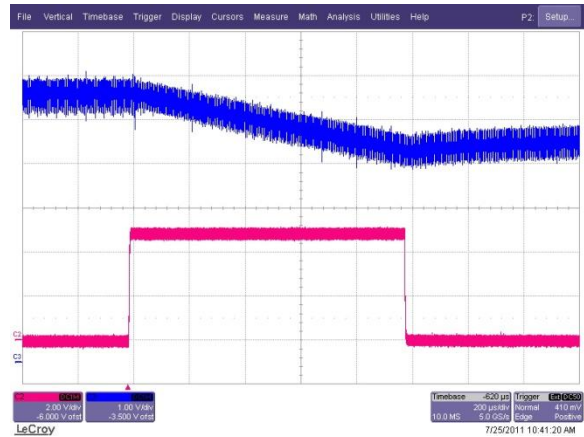


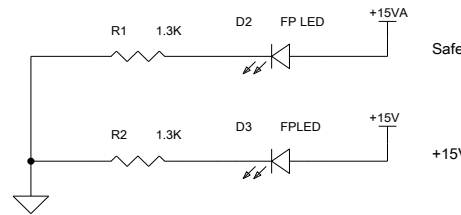
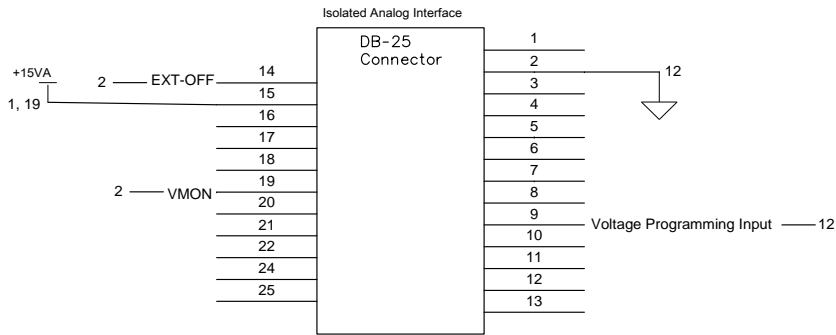
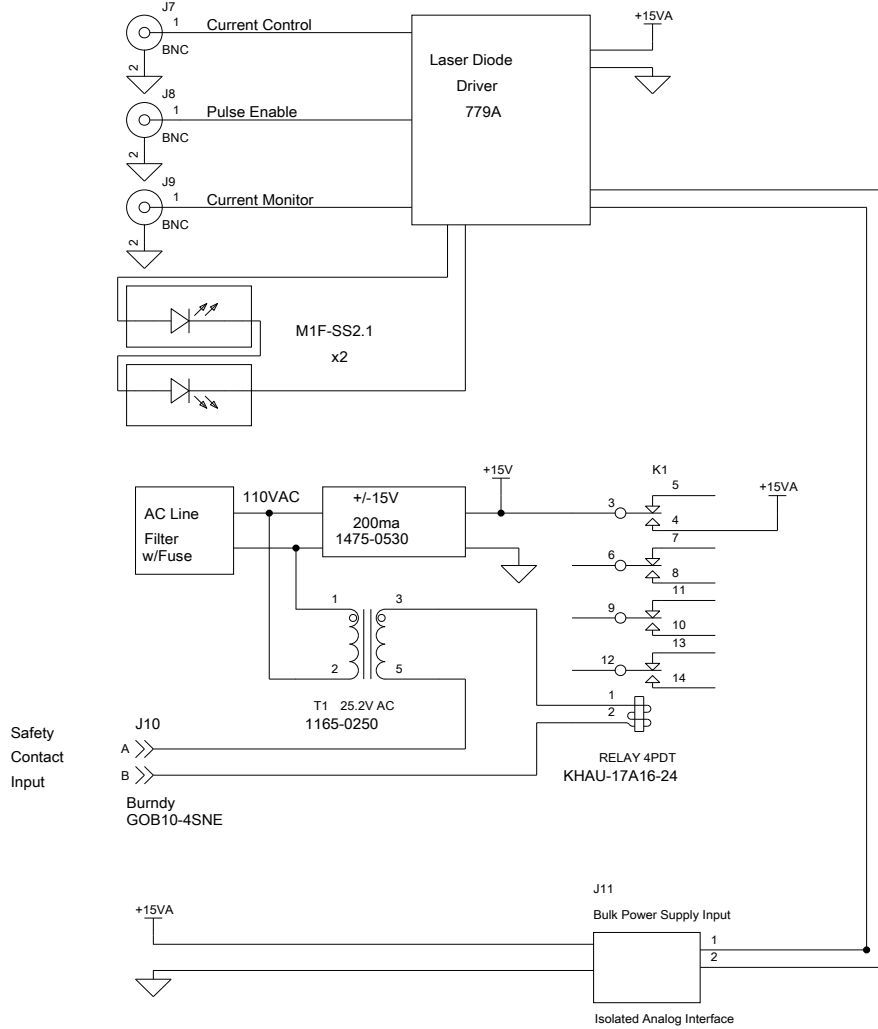
Figure [18]: 100 A flat top at 6.1 V control voltage.

Conclusion & Future Work

These tests confirmed usability of the diode pump chassis for future production and use. Other additions can include the installation of a fan, the possible swap of different components, the insertion of parallel capacitors, and the repositioning of the heat sink on the outside of the chassis. The most important operation specification is to drive the diode driver between 3.5 V to 24.2 V.

Appendix

A) Circuit Diagram



Note: +15VA voltage is controlled by the Safety input contact.

B) Matlab *power_supply_control* GUI for Analog control of the Bulk Supply

Interface

