



**DIRECTED ENERGY, INC.**

**LDX-100  
PULSED LASER DIODE DRIVER  
OPERATION MANUAL**

SERIAL NUMBER: \_\_\_\_\_

DATE: \_\_\_\_\_

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\*\*\*\*\* WARNING \*\*\*\*\*

SAFE OPERATING PROCEDURES AND PROPER USE OF THE EQUIPMENT ARE THE RESPONSIBILITY OF THE USER OF THIS SYSTEM.

Directed Energy, Inc (DEI) provides information on its products and associated hazards, but it assumes no responsibility for the after-sale operation and safety practices.

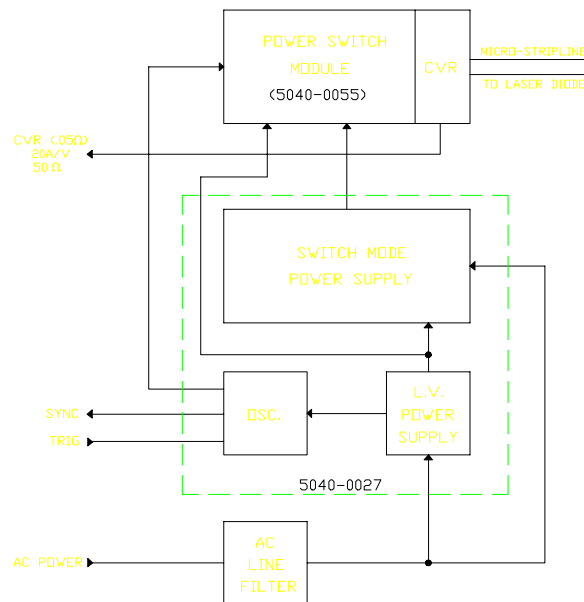
ALL PERSONNEL WHO WORK WITH OR ARE EXPOSED TO THIS EQUIPMENT MUST TAKE PRECAUTIONS TO PROTECT THEMSELVES AGAINST POSSIBLE SERIOUS AND/OR FATAL BODILY INJURY. DO NOT PERFORM INTERNAL REPAIR OR ADJUSTMENTS UNLESS ANOTHER PERSON CAPABLE OF RENDERING FIRST AID AND RESUSCITATION IS PRESENT.

## 1.0 GENERAL DESCRIPTION

The DEI LDX-100 Laser Diode Driver is a high voltage solid state pulse generator designed to drive low inductance, resistive loads such as LEDs and laser diodes.

The driver utilizes a patented state-of-the-art high-speed power MOSFET as the high voltage switch, incorporated into a low impedance configuration featuring a multi-layer stripline-style output bus.

Referring to the figure below, the power switch module (DEI #5040-0055) provides the pulsed power to the micro-strip transmission line, and in turn to the laser diode. The current viewing resistor, labeled "CVR", allows the user to monitor the pulse current supplied to the laser diode.



*Figure 1*  
*LDX-100 Block Diagram*

The power switch module receives power from the switch mode power supply module (DEI #5040-0027). This module also contains a low voltage power supply, providing support power to the switch mode supply, and an internal oscillator.

The internal oscillator provides a drive pulse to the power switch module to gate on and off the output current pulse. The oscillator may be operated in either an internal or an external mode. In external mode, the trigger line provides the pulse recurrence frequency (PRF), while the Laser Diode Driver provides the pulse

width through the "Pulse Width" potentiometer. A sync line is provided from the oscillator, allowing the user to synchronize an oscilloscope to view the current pulse generated by the Laser Diode Driver.

## **2.0 SPECIFICATIONS**

All specifications are measured into a shorted output.

<b>PARAMETER</b>	<b>VALUE</b>
<b><u>PULSE OUTPUT</u></b>	
Polarity	Positive
Maximum Current	100A
Maximum Duty Cycle	0.0004
Means of Adjustment	Front Panel
Output Connector	Micro-Stripline, Rear Panel
<b><u>TRIGGER</u></b>	
Trigger Source	Internal or External
Trigger Input (External)	+5V $\pm$ 1V, into 50 $\Omega$
Trigger Rise Time (External)	<20ns
Minimum Trigger Pulse Width (External)	100ns
Input Trigger Connector	Type BNC, Front Panel
<b><u>OUTPUT PULSE ELECTRICAL CHARACTERISTICS</u></b>	
Pulse Rise Time	<20ns (10%-90%)
Pulse Width	<25ns to >1 $\mu$ s
Pulse Width Adjustment	Front Panel
Pulse Recurrence Frequency	Single Shot to 10KHz controlled by external trigger, 50Hz to 10KHZ controlled by internal trigger
Drop (At maximum rated current and 200ns pulse width)	<5%
Over/undershoot	<5%
Jitter	<0.5ns shot-to-shot
Sync Monitor	TTL output into high impedance
Sync Monitor Connector	Type BNC, Front Panel
CVR Monitor	20A/1V into 50 $\Omega$
CVR Monitor Connector	Type BNC, Front Panel
<b><u>GENERAL</u></b>	
Input AC Power	110/220VAC, 50/60Hz
Dimensions	171 mm x 254 mm x 89 mm
Weight	Approx. 3.6kg (8lbs)

### **3.0 SAFETY**

The high voltage nature of this device dictates the use of caution when operating or servicing this equipment. The following is a summary of general safety precautions that must be observed during all phases of operation and repair of the LDX-100.

#### **3.1 Operating Safety Summary**

The safety information contained in this summary is for both operating and servicing personnel. Specific warnings may be found throughout this manual, but may not appear in this summary.

##### **3.1.1 Grounding**

The driver is grounded through the grounding conductor of the AC power cord. To avoid electrical shock, plug the driver into a properly wired receptacle before making connection to any input or output connectors. Use only a power cord that is in good condition.

##### **3.1.2 Cover Removal**

To avoid personal injury, do not remove the covers. Do not operate the driver while the covers are removed. The covers do not contain safety interlocks!

##### **3.1.3 General Operating Precautions**

**WARNING: The internal energy storage capacitors can remain charged for 15 minutes after power is turned off. Handle the output cable and load with extreme caution.**

Do not remove the input or output cables while the driver is in operation. Failure to observe these precautions can result in potential electric shock to personnel, arcing, and damage to the connectors and system.

Any pulsed power system is capable of random triggering via transients. Therefore when the driver is turned on, or high voltage is present in the chassis, assume it is possible to get a pulse on the output connector.

#### **3.2 Servicing Safety Summary**

The driver contains dangerous voltages and stored energy. DEI strongly recommends that all repairs and adjustments be performed by factory qualified personnel. DEI will not be responsible for personal injury or damage to the driver that occurs during repair by any party other than the factory.

### 3.2.1 Servicing Procedure

Do not perform internal repair or adjustments unless another person capable of rendering first aid and resuscitation is present.

### 3.2.2 Internal Energy Storage

**The driver contains capacitors that are used as energy storage elements. When charged, these capacitors contain in excess of 13 Joules of stored energy. This is sufficient energy to cause serious injury or death.** Assure that the AC power cord is disconnected from the driver, and that the capacitor bank is fully discharged and a shorting strap installed before any repairs or adjustments are attempted. Verify with a voltmeter that all circuits are de-energized before servicing. The voltmeter used to make these measurements must be certified for use at 1000VDC and 220VAC or greater. Dangerous voltages, floating ground planes and energy storage exist at several locations in the driver. Touching connections and/or components could result in serious injury.

## 4.0 OPERATING CONSIDERATIONS

### 4.1 Output

**WARNING: The internal energy storage capacitors can remain charged for 15 minutes after power is turned off. Handle the output cable and load with extreme caution.**

The driver is designed to operate into a laser diode load with a small inductive term (typically less than 60 nanohenrys). An improperly terminated output will cause excessive aberrations on the output waveform and could possibly damage the driver. To ensure that this does not occur, observe the following precautions:

- Use good quality cable and connectors;
- Make all external connections tight and as short as possible;
- Ensure that all external cables and hardware have adequate voltage and power ratings;
- Be extremely careful not to short the output of the driver to ground during operation, as this could cause damage to the driver.

### 4.2 Pulse Risetime and Falltime

The physical and electrical characteristics of the cable transmitting the pulse determine the characteristic impedance, velocity of propagation and the amount of signal loss. Several feet of cable can attenuate high frequency information in a pulse with a fast rise time. It is therefore important to keep these cables as short as

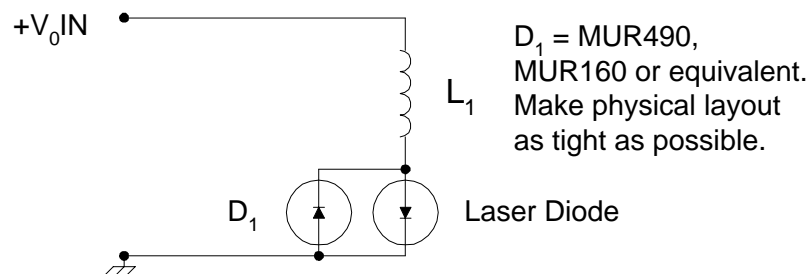
is practical. For optimum performance, DEI recommends using the micro-strip transmission line provided with the driver. When signal comparison measurements or time difference determinations are made, the two signals from the test device should travel through coaxial cables with identical loss and time delay characteristics.

### **4.3 Impedance Matching**

If a pulse travels down a transmission line and encounters a mismatch, a reflection is generated and sent back along the line to the source. The amplitude and polarity of the reflection are determined by the impedance mismatch. If the reflected signal returns before the output pulse ends, it is terminated by the internal series resistor. This will cause minimal distortion of the pulse shape and amplitude.

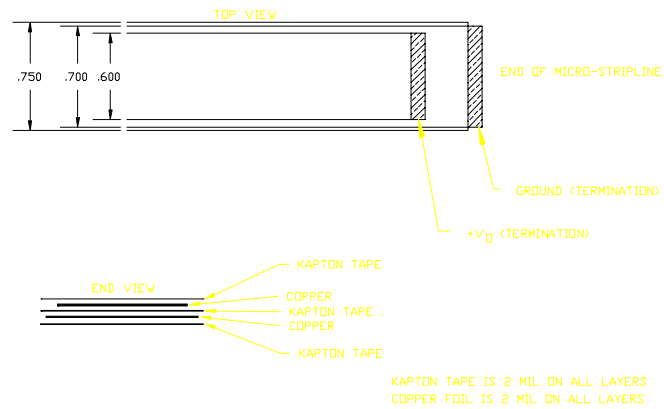
### **4.4 Load Interconnection**

Figure 2 shown below depicts a schematic diagram of the preferred termination of the micro-stripline. D1 is a fast-recovery diode, wired in the reverse direction across the laser diode. This clamps negative-going transients which are created by the inductive term L1 present in all laser diode electrical connections. (L1 represents the inductance present in the diode package and interconnections, and is not a discrete inductor in the circuit.) It is important to keep the value of L1 as small as possible by using extremely short leads.



*Figure 2*  
*Output Strip-line Termination*

Figure 3 below shows the end of the micro-stripline. Its impedance is approximately  $2.5\Omega$ . The laser diode should be connected to the micro-stripline using the circuit shown in Figure 2. All leads should be kept as short as possible. A few nanohenrys of inductance can have a substantial impact on the output pulse shape.



*Figure 3*  
*Output Strip-line Topology*

#### **4.5 Trigger Input**

When in external mode, an input trigger of  $+5V \pm 1V$  into  $50\Omega$  with a risetime of  $<20ns$  is required to trigger the driver. Departure from these values can result in a loss of performance. These trigger requirements are met by any high quality low voltage pulse generator. The trigger should be set to  $+5V \pm 1V$  into  $50\Omega$  before the trigger cable is attached to the driver trigger input.

### **5.0 PREPARATION FOR USE**

#### **5.1 General**

After unpacking, initial inspection and preliminary electrical check procedures should be performed to assure that the unit is in good working order. If it is determined that the unit is damaged, the carrier should be notified immediately. Repair problems should be directed to the service department, Directed Energy, Inc. (DEI), Fort Collins, Colorado. Telephone: (970) 493-1901.

#### **5.2 Initial Inspection**

1. Inspect unit for exterior mechanical damage.

2. Inspect power input cord and input power module for obvious signs of damage.

### **5.3 Input Power Cord**

The input power cord terminates externally in a three-prong polarized plug. The unit chassis is wired to the plug through the line cord, and therefore, the insertion of the plug into a compatible receptacle, hooked up to a grounded input, will automatically ground the unit. The unit should not be operated without a grounded AC input!

## **6.0 OPERATING INSTRUCTIONS**

### **6.1 Controls And Indicators**

#### **6.1.1 Key Switch and POWER Lamp**

The front panel key switch controls all AC power in the chassis. Rotating the key switch to the ON position will activate the driver. The POWER lamp located above the key switch illuminates when AC power is turned on.

#### **6.1.2 OVERLOAD Indicator**

The OVERLOAD lamp flashes when a fault condition is encountered. Fault conditions include an internal or external short, or an output power requirement in excess of the capabilities of the high voltage power supply. If the OVERLOAD light illuminates, the unit should not be operated until the cause of the fault is rectified. In the event of excess power requirements, the power should be reduced by decreasing the pulse recurrence frequency, decreasing the output pulse width, lowering the power, or some combination thereof, until the OVERLOAD indicator extinguishes. If these actions fail to extinguish the lamp, a problem exists with the laser diode or with the driver itself.

#### **6.1.3 POWER Adjustment Potentiometer**

This potentiometer controls the output voltage pulse (or level of current pulse, depending on load resistance).

If the output current exceeds 100A, the LDX-100 will inhibit output pulses, and the LASER ON LED will extinguish. If this occurs, lower the power (by turning the POWER potentiometer counter-clockwise), and reset the LDX-100 by turning the LASER ON Switch OFF and ON.

**CAUTION: When operating at pulse widths from 20ns to approximately 40ns, peak current will increase as pulse width is increased.**

#### **6.1.4 PULSE WIDTH Adjustment Potentiometer**

Pulse width is adjusted with the potentiometer labeled PULSE WIDTH. This adjustment functions when the driver is either internally or externally triggered.

**CAUTION: When operating at pulse widths from 20ns to approximately 40ns, peak current will increase as pulse width is increased.**

#### **6.1.5 FREQUENCY Adjustment Potentiometer**

When internally triggered, the pulse recurrence frequency is controlled by the "Frequency" potentiometer. When externally triggered, this control is disabled.

#### **6.1.6 MONITOR BNC Connector**

The BNC connector labeled MONITOR provides a high-speed monitor of the output current pulse. This output can be monitored using a high-speed oscilloscope. Its output is 20A/1V, and should be terminated into 50Ω.

#### **6.1.7 SYNC BNC Connector**

The BNC connector labeled "SYNC" replicates the width and frequency of the output pulse, and is used to synchronize an oscilloscope to the output pulse. Output is nominal TTL high level into a high impedance.

#### **6.1.8 TRIGGER BNC Connector and Switch**

The BNC connector labeled "TRIGGER" is the input to externally trigger the laser diode driver. The trigger line provides the pulse recurrence frequency (PRF), while the pulse width is controlled through the "Pulse Width" potentiometer. An input trigger of +5V ±1V into 50Ω with a risetime of <20ns is required to trigger the driver. When externally triggered, the "Trigger" switch should be set to EXT.

#### **6.1.9 LASER ON Switch and Indicator**

The switch labeled LASER ON enables and inhibits output pulses. When the output is enabled, the LASER ON indicator illuminates.

If the output current exceeds 100A, the LDX-100 will inhibit output pulses, and the LASER ON indicator will extinguish. If this occurs, lower the power (by turning the POWER potentiometer counter-clockwise), and reset the LDX-100 by turning the LASER ON Switch OFF and ON.

### **6.1.10 PULSE OUTPUT Connector**

The 15 pin rear panel DSUB connector is the driver's pulse output. The lower row is ground, and the upper row is the pulse output. The driver should only be operated with the factory-provided output stripline cable.

### **6.1.11 INTERLOCK BNC Connector**

The rear panel BNC connector is an interlock connection. When this interlock is broken, pulse output is inhibited. This interlock can be connected to an external switch (such as a door switch) to inhibit operation if the switch is opened.

## **6.2 Operation**

Before turning on the unit, ensure that all output adjustments are set to ZERO, and the output micro-stripline is connected to an appropriate load.

**CAUTION: Never operate the LDX-100 without a load connected to the output connector. To operate without a laser diode, either attach an appropriate dummy load to the output stripline, or short the two conductors of the output stripline using multiple jumpers to keep the inductance as low as possible.**

The output pulse should be monitored at the load with a high speed oscilloscope and appropriate probes and/or attenuators, or using the LDX-100's internal current monitor.

Turn ON the AC power, turn ON the LASER ON switch, and slowly increase the Power, Pulse Width and Frequency adjustments while monitoring the oscilloscope until the appropriate output is generated. If the OVERLOAD lamp illuminates, reduce power, frequency or pulse width until the lamp extinguishes. If the lamp does not extinguish, if there is no output from the driver, or the output is severely distorted, set the Power Adjust to zero. **Leave the driver connected to the AC input without high voltage and with all connectors in place for approximately 15 minutes to bleed off the stored energy**, then disconnect the AC power to the unit and refer to the Troubleshooting Section of this manual.

**WARNING: Do not exceed the maximum rated output current, duty cycle or pulse width. (See Specifications, Section 2.0.) Operating the driver beyond its maximum rated values may damage the unit.**

## **6.3 Power-Down Procedures**

**CAUTION: The internal energy storage capacitors can remain charged for 15 minutes after power is turned off. Handle the output cable and load with extreme caution.**

1. Set the Power Adjust dial to zero.
2. Leave the driver connected to the AC input without high voltage and with all connectors in place for approximately 15 minutes to bleed off the stored energy.
3. Turn OFF the unit.
4. Disconnect the AC power to the unit.

## **7.0 TROUBLESHOOTING**

### **WARNING**

The driver contains capacitors that are used as energy storage elements. When charged, these capacitors contain in excess of 13 joules of stored energy. This is sufficient energy to cause serious injury or death. Assure that the AC power cord is disconnected from the driver, and that the capacitor bank is fully discharged and a shorting strap installed before any repairs or adjustments are attempted. Verify with a voltmeter that all circuits are de-energized before servicing. The voltmeter used to make these measurements must be certified for use at 1000VDC and 220VAC or greater. Dangerous voltages, floating ground planes and energy storage exist at several locations in the driver. Touching connections or components could result in serious injury.

### **7.1 Troubleshooting Procedures**

Before attempting to service or troubleshoot the driver, review the servicing safety summary in Section 3.0.

The power MOSFETs utilized in the driver are mounted underneath the printed circuit board, and utilize the mounting plate as a heat sink. In the unlikely event that a MOSFET need be replaced, it is highly recommended that the unit be returned to the factory for servicing.

The table below summarizes potential problems and their solutions. If these recommendations do not resolve the problem, DEI customer service can be contacted for further assistance.

<b>SYMPTOM</b>	<b>SOLUTIONS</b>
1. No AC ON Lamp.	<ul style="list-style-type: none"> <li>• AC power not plugged in.</li> <li>• Fuse(s) are blown. See fuse replacement instructions in Section 7.1.1</li> </ul>
2. No output pulse.	<ul style="list-style-type: none"> <li>• No input trigger.</li> <li>• Input trigger voltage too low.</li> </ul>

- Input trigger pulse width too short. Increase width.
- Input trigger frequency too high. Reduce frequency.
- Trigger switch incorrectly set.
- High voltage supply set too low. Increase high voltage setting.
- LASER ON switch is not turned on. Turn ON the LASER ON switch.
- Output current exceeds 100A. Reduce POWER potentiometer and reset unit by turning LASER ON switch OFF and ON.
- Rear panel INTERLOCK BNC is open. Close INTERLOCK contacts.
- Output not connected correctly. Check all cables and connections.
- Driver is damaged. Contact DEI customer service.

### **7.1.1 Fuses**

To avoid fire hazard or damage to the driver, use only fuse values indicated on the rear panel silkscreen. Fuse replacement should be performed by qualified personnel only. **Assure that the AC power cord is disconnected from the driver before fuse replacement is attempted.**

The fuses are located in the power entry module on the rear panel.

### **7.2 Factory Service**

If the procedures above fail to resolve an operational problem, please contact the factory for further assistance:

DIRECTED ENERGY, INC.  
2401 RESEARCH BLVD  
SUITE 108  
FORT COLLINS, CO 80526  
(970) 493-1901  
FAX (970) 493-1903

## **8.0 SYSTEM FAILURE MODES**

The LDX-100 is capable of generating large amplitude current pulses with very fast rise and fall times. There is limited over-current or over-voltage protection circuitry, and it is the user's responsibility to assure that the interconnect cables and load do not create transients, over-current or over-voltage conditions that could damage the pulse generator.

### **8.1 Over-Current Failure**

When the output is shorted, the driver can deliver over 100A of current (depending on cabling, HV power supply setting, etc.). A current pulse in excess of the driver's maximum specifications may cause damage to the driver, load and/or associated cabling. The power control should never be adjusted for more than 100A of pulse current.

### **8.2 Over-Voltage Failure**

From transmission line theory it is known that a voltage pulse launched onto an open cable will cause the voltage to reflect back down the cable and double in amplitude. This voltage doubling will over-voltage the MOSFET and lead to driver failure. Turning on the driver with the load disconnected or opening the load while the driver is operating may cause it to fail due to this voltage doubling effect. The unit must never be operated without the output cable connected to a proper load.

## **9.0 WARRANTY**

There are no warranties, express or implied, including any implied warranty of fitness for a particular purpose nor any IMPLIED WARRANTY OF MERCHANTABILITY made by Directed Energy, Inc. (DEI) except as follows:

DEI warrants equipment manufactured by it to be free from defects in materials and/or workmanship under conditions of normal use for a period of one year from the date of shipment to the purchaser. DEI will repair or replace, at DEI's option, any product manufactured by it which is shown to be defective or fails to perform within specifications within one year from the date of shipment to the purchaser. OEM, modified and custom items of equipment are similarly warranted, for a period of ninety (90) days from date of shipment to the purchaser.

Equipment claimed to be defective must be returned, transportation prepaid, to DEI's factory in Fort Collins, Colorado within the warranty period. Returns must be preauthorized by contact with DEI's customer service department. Written documentation of such preauthorization shall be included with the returned item.

At DEI's discretion, DEI may elect to repair or replace the equipment claimed to be defective or refund the original purchase price, plus taxes and transportation charges incurred by the purchaser.

This Warranty shall not apply to any product that has been:

1. Repaired, worked on, or altered by persons unauthorized by DEI;
2. Subjected to misuse, neglect, or damage by others; or
3. Connected, installed, adjusted, or used in a manner not authorized in the instructions or specifications furnished by DEI.

This warranty is the purchaser's sole remedy for claimed defects in the equipment sold or manufactured by DEI. DEI's liability to the purchaser is limited to the repair or replacement of the claimed defective equipment or, at DEI's option, refund of the purchase price, taxes and transportation charges incurred by the purchaser. DEI will not be responsible for or liable to the purchaser for consequential losses or damages asserted to be attributable to a claimed defect in the equipment provided.

Changes made by DEI in the design or manufacture of similar equipment which are effected subsequent to the date of shipment of the warranted equipment to the purchaser are reflective of DEI's program of constant product development and improvement and shall not be construed as an acknowledgement of deficiency in the product shipped to purchaser. DEI will be under no obligation to make any changes to product previously shipped.