



# FPX800 PULSER OPERATION MANUAL

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

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

Directed Energy, Inc.  
2301 Research Blvd., Ste. 105  
Fort Collins, Colorado 80526  
970/493-1901 FAX 970/493-1903

## TABLE OF CONTENTS

1.0 GENERAL DESCRIPTION .....	3
2.0 SPECIFICATIONS .....	4
3.0 SAFETY .....	5
3.1 Operating Safety Summary .....	5
3.1.1 Power Source .....	5
3.1.2 Grounding.....	5
3.1.3 Cover Removal.....	5
3.1.4 General Operating Precautions .....	5
3.2 Servicing Safety Summary .....	5
3.2.1 Servicing Procedure .....	6
3.2.2 Internal Energy Storage.....	6
4.0 OPERATING CONSIDERATIONS.....	7
4.1 Output .....	7
4.2 Pulse Risetime and Faltime .....	7
4.3 Impedance Matching.....	7
4.4 Trigger Input.....	7
4.5 High Voltage Input.....	8
4.6 Maximum Duty Cycle .....	8
5.0 PREPARATION FOR USE .....	9
5.1 General .....	9
5.2 Initial Inspection .....	9
5.3 Electrical Installation.....	9
5.3.1 Input Power Cord.....	9
5.4 Mechanical Installation .....	9
5.5 Electrical Check .....	9
5.5.1 Power-Up .....	9
6.0 OPERATING INSTRUCTIONS.....	11
6.1 Power-Up Procedures .....	11
6.2 Power-Down Procedures .....	11
7.0 TROUBLESHOOTING.....	12
7.1 Troubleshooting Procedures .....	12
7.1.1 Fuses.....	13
7.2 Factory Service .....	13
8.0 SYSTEM FAILURE MODES .....	14
9.0 WARRANTY .....	14
APPENDIX A .....	15

\*\*\*\*\* **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 FPX800 Pulser is a high voltage solid state pulse generator designed to drive low inductance, resistive loads, typically into 50 ohms. The pulser is protected against operation into arcs, short circuits and open circuits, and against load transients. The FPX800 is designed as an instrument for lab experiments, calibration, component testing, beam steering, gating PMTs and MCPs, and other applications that require very fast and clean high speed pulses, or incorporated into an OEM system.

The FPX800 utilizes a high-speed power MOSFET as the high voltage switch, incorporated into a low impedance configuration featuring a multi-layer stripline-style output bus.

The FPX800 requires an external high voltage DC supply (800V maximum), and an input trigger. The unit is available in either positive or negative polarities.

**2.0 SPECIFICATIONS**

<b>OUTPUT</b>	
Range	0 to 800V into open circuit, >750V into 50Ω
Peak Current	>30A maximum (1)
Polarity	Positive or Negative (2)
Adjustment	High voltage input
Connector Type	BNC
<b>HIGH VOLTAGE INPUT</b>	
Input Voltage Range	0 to 800VDC
Connector Type	N
Polarity	Positive or negative. Polarity of input power supply must be the same as the polarity of the FPX800
<b>OUTPUT PULSE CHARACTERISTICS</b>	
Rise and Fall Time	<30ns (3)
Pulse Width	<80ns to 10μsec (3)
Pulse Width Adjustment	Gate input pulse width
Pulse Recurrence Frequency	Single shot to 10KHz, 2MHz burst
Duty Cycle	0.01 maximum
Droop	<10%, 3μsec pulse (3)
Over/undershoot	<5% (3)
Jitter	<0.5ns shot to shot
<b>TRIGGER</b>	
Input Level	+5V ±1V into 50Ω
Rise Time	<10ns
Maximum Pulse Width	10μsec
<b>GENERAL</b>	
Input AC Power	110/220VAC, 50/60Hz (2)
Dimensions	9.4"L x 4.9"W x 1.7"D
Weight	Approximately 2.8 lbs.

(1) The current is internally limited to approximately 35A peak. Limiting the average input power to 15W will allow the unit to operate indefinitely into a short or open circuit without being damaged.

(2) Factory set, specified at time of order.

(3) Operation into 50Ω, 800VDC input power.

### **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 FPX800 Pulser.

#### **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 Power Source**

The FPX800 is designed to operate from a power source that will not apply more than 220 volts between the supply conductors or between either supply conductor and ground. A protective grounding connection by way of the grounding conductor in the AC power cord is essential.

##### **3.1.2 Grounding**

The FPX800 is grounded through the grounding conductor of the AC power cord. To avoid electrical shock, plug the FPX800 into a properly wired receptacle before making connection to any input or output connectors. Use only a power cord that is in good condition.

##### **3.1.3 Cover Removal**

To avoid personal injury, do not remove the cover. Do not operate the FPX800 while the cover is removed. The cover does not contain a safety interlock!

##### **3.1.4 General Operating Precautions**

Do not remove the input or output cables while the pulser is in operation. Never short-circuit the high voltage output of the pulse generator. Failure to observe these precautions can result in potential electric shock to personnel, arcing, and damage to the connectors and system.

The top cover of the pulse generator is not safety interlocked. Extreme caution should be exercised when removing the cover.

Any pulsed power system is capable of random triggering via transients. Therefore when the pulse generator 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 FPX800 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 pulser 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 FPX800 contains capacitors that are used as energy storage elements. When charged, these capacitors contain in excess of 1.5 joules of stored energy. This is sufficient energy to cause serious injury. Assure that the AC power cord is disconnected from the pulser, 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 FPX800. Touching connections and/or components could result in serious injury.

## **4.0 OPERATING CONSIDERATIONS**

### **4.1 Output**

The FPX800 is designed to operate into a load whose characteristic impedance is 50 ohms, and is protected against most arc, short circuit and transient conditions. An unterminated or improperly terminated output will cause excessive aberrations on the output waveform and could possibly damage the pulser. To ensure this does not occur, observe the following precautions:

- Use good quality 50 ohm coaxial cable and connectors;
- Make all external connections tight and as short as possible;
- Use good quality attenuators and/or loads. If using an attenuator, DEI recommends the Weinschel Engineering model 45-40-33. Small attenuators will not work correctly and can be harmed by the FPX800;
- Use terminators or impedance-matching devices to avoid reflections;
- Ensure that all external cables and hardware have adequate voltage and power ratings;
- Be careful not to short the output of the pulser to ground, as this can cause damage to the pulser.

The FPX800 can be used to drive capacitive, inductive and resistive loads other than 50 ohms. Please consult the factory for further applications information.

### **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 interconnecting cable lengths of 8" or less. 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 adds or subtracts from the amplitude of the pulse. This will distort the pulse shape and amplitude.

### **4.4 Trigger Input**

An input trigger of +5V +/-1V into 50 ohms with a risetime of <10ns is required to gate on the FPX800. 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 +/-1V into 50 ohms before the trigger cable is attached to the FPX800 trigger input. The input trigger is transformer-coupled into a DS0026 CMOS Clock Driver which does not appear resistive to the input pulse generator. For this reason, the input trigger amplitude should be set using a 50 ohm load (e.g. a 50 ohm scope input) before connecting it to the FPX800. If the trigger input is greater than +5V into 50 ohms, pulse stretching can occur.

#### **4.5 High Voltage Input**

The FPX800 is rated at a maximum input voltage of 800VDC. Proper precautions should be taken by the user to ensure that the maximum voltage is not exceeded.

#### **4.6 Maximum Duty Cycle**

The case of the FPX800 (specifically the bottom panel) is used as the heat sink for the power circuitry. Therefore the case can get hot! Use caution when handling the FPX800 after operation. The duty cycle is limited by the cooling capabilities of the FPX800. Higher duty cycles can be obtained by forced air cooling of the enclosure, or for very high power applications (>1Kw), bolting the FPX800 to a water or air cooled heat sink.

## **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.
3. Remove top cover retaining screws. Inspect components and printed circuit board for damage.

### **5.3 Electrical Installation**

Standard units are shipped ready for use with a nominal 110 VAC input. The unit can be configured for 220VAC input from the factory.

#### **5.3.1 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!

### **5.4 Mechanical Installation**

As received, the unit is ready for bench use. If necessary, the unit can be bolted to an external heat sink for additional cooling (see Section 4.6 above) using the mounting flanges.

The FPX800 is extremely rugged, and can be mounted to other equipment, hardware or benches using the mounting flanges. Physical orientation is not critical.

### **5.5 Electrical Check**

Before proceeding, please review the precautions in Section 3.

#### **5.5.1 Power-Up**

The unit should be powered up using the following procedures:

1. Ensure that the high voltage power supply is turned off, and all controls set to zero volts.

2. Before connecting the pulse generator to the FPX800, set up the pulse generator output to deliver a 5V pulse (+/-1V) into 50 ohms, with a rep rate of approximately 5KHz, and a pulse width of 200-500ns.
3. Plug the power cord into the AC power input. The red indicator light should turn on, indicating that the FPX800 is operational. If this does not occur, unplug the unit from the AC power, and refer to the Troubleshooting Section of this manual.
4. Connect the cable from the high voltage power supply to the N connector of the FPX800 labeled "HV IN, 950V MAX".
5. Connect the pulse generator to the BNC connector of the FPX800 labeled "TRIGGER INPUT".
6. Connect an appropriate load to the BNC connector of the FPX800 labeled "OUTPUT".
7. Monitor the voltage across the load, utilizing an appropriate attenuator.
8. Turn ON the high voltage power supply. Slowly increase the power supply to 100VDC. The FPX800 should produce an output pulse of approximately 95V, with a pulse width and pulse recurrence frequency following that of the incoming trigger.
9. If there is no output from the FPX800, or the output is severely distorted, set the output voltage of the high voltage power supply to zero and turn off the high voltage power supply. Leave the FPX800 connected to the AC input without high voltage and with all connectors in place for approximately one minute to bleed off the stored energy, then disconnect the AC power to the unit and refer to the Troubleshooting Section of this manual.

## **6.0 OPERATING INSTRUCTIONS**

### **WARNING**

1. To avoid personal injury, do not remove the cover. Do not operate the FPX800 while the cover is removed. The cover does not contain a safety interlock!
2. Do not remove the input or output cables while the pulser is in operation. Never short-circuit the high voltage output of the pulse generator. Failure to observe these precautions can result in potential electric shock to personnel, arcing, and damage to the connectors and system.
3. The top cover of the pulse generator is not safety interlocked. Extreme caution should be exercised when removing the cover.
4. Pulsed power systems are capable of random triggering via transients and therefore when the pulse generator is turned on, or high voltage is present in the chassis, assume it is possible to get a pulse on the output connector.

### **6.1 Power-Up Procedures**

The unit should be powered up using the procedures detailed in Section 5.5.1. When this is accomplished, the pulser can be adjusted for the particular application through the following procedure:

1. Monitoring the output of the FPX800 on an oscilloscope utilizing an appropriate attenuator, set the output amplitude of the FPX800 to the desired level by adjusting the high voltage power supply.
2. Set the output pulse width and pulse recurrence frequency by varying the controls of the input pulse generator. The output pulse width should be set by monitoring the output of the FPX800. The output high voltage will follow the input trigger, but will not replicate in time the exact duration of the input trigger due to the system propagation delay.

### **6.2 Power-Down Procedures**

1. Set the output voltage of the high voltage power supply to zero and turn off the high voltage power supply.
2. Leave the FPX800 connected to the AC input without high voltage and with all connectors in place for approximately one minute to bleed off the stored energy.
3. Disconnect the AC power to the unit.

## **7.0 TROUBLESHOOTING**

### **WARNING**

The FPX800 contains capacitors that are used as energy storage elements. When charged, these capacitors contain in excess of 1.5 joules of stored energy. This is sufficient energy to cause serious injury. Assure that the AC power cord is disconnected from the pulser, 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 FPX800. Touching connections or components could result in serious injury.

### **7.1 Troubleshooting Procedures**

Before attempting to service or troubleshoot the FPX800, review the servicing safety summary in Section 3.0.

The power MOSFET utilized in the FPX800 is mounted underneath the printed circuit board, and utilizes the case as a heat sink. In the unlikely event that the 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. Red LED does not illuminate	-AC power not plugged in. -Fuse(s) are blown. See fuse replacement instructions in Section 8.1.1.
2. No output pulse.	-No input trigger. -Input trigger voltage too low. -Input trigger pulse width too short. Increase width. -Input trigger frequency too high. Reduce frequency. -No input high voltage. Check HV supply and connections. -High voltage power supply is the wrong polarity. Make sure power supply polarity agrees with the FPX800's polarity. -Output not connected correctly. Check all cables and connections.

-Pulser is damaged. Contact DEI customer service.

### **7.1.1 Fuses**

To avoid fire hazard or damage to the pulser, use only 1A fast blow fuses (Littlefuse #312001 or equivalent). Fuse replacement should be performed by qualified personnel only. Assure that the AC power cord is disconnected from the pulser, and that the capacitor bank is fully discharged and a shorting strap installed before fuse replacement is 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.

The fuses are located in the corner of the printed circuit board, adjacent to the power entry module.

### **7.2 Factory Service**

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

DIRECTED ENERGY, INC.  
2301 RESEARCH BLVD SUITE 105  
FORT COLLINS, CO 80526  
(970) 493-1901 FAX (970) 493-1903

## **8.0 SYSTEM FAILURE MODES**

The FPX800 pulse generator is capable of generating large amplitude current pulses with very fast rise and fall times. There is over-current and over-voltage protection circuitry, and limiting the average input power to 15W will allow the unit to operate indefinitely into a short or open circuit without being damaged. However it is the user's responsibility to assure that the pulse generator does not operate into a sustained over-voltage or over-current condition in excess of this maximum power. The input DC voltage should never exceed 800V. FAILURE TO DO SO MAY DAMAGE THE PULSER, AND VOIDS THE WARRANTY.

## **9.0 WARRANTY**

Directed Energy, Inc. (DEI) warrants all parts of equipment of its manufacture to be free from defects caused by faulty material or poor workmanship. Directed Energy, Inc's obligation is limited under the warranty to repair or replacement of products in kind. Returns must be accompanied by a Directed Energy, Inc. return authorization number and conform to standard conditions for adjustment. The aforesaid warranty shall expire twelve (12) months following the day of shipment from Directed Energy, Inc's plant. The foregoing states the entire warranty extended by Directed Energy, Inc. No other warranty, expressed or implied, is made and, specifically, Directed Energy, Inc. makes no warranty of merchantability or fitness for any purpose. In no case shall Directed Energy, Inc. be liable for any special or consequential damages. Authorization must be obtained prior to return of defective items.

**APPENDIX A**  
**SCHEMATICS**