DIRECTED ENERGY, INC.

PVX–4130
±6,000V Pulse Generator

OPERATION MANUAL

SERIAL NUMBER:_____

DATE:_____

Directed Energy, Inc.
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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 PVX-4130 pulser is a high voltage solid state pulser designed to drive capacitive loads such as acceleration grids and deflection plates.

The PVX-4130 will generate an output voltage swing of 6000 volts, and output current of 30 amperes peak and 0.1 amperes continuous. It produces very flat voltage pulses to DC into a capacitive load.

The PVX-4130 Pulser can generate single-ended output pulses from ground to +6000V or from ground to -6000V, and can also generate pulses originating from a voltage offset from ground. This offset can be from -6000V to +6000V, with a maximum power supply voltage differential (V_{high} - V_{low}) ≤6000V.

2.0 SPECIFICATIONS

All specifications are measured into a 50pF load connected with 4 feet (~1.2m) of RG-58 (50Ω) coaxial cable

INPUT DC VOLTAGE +V IN (V_{high})	
Source	External
Absolute Maximum Value	+6000 volts
Absolute Minimum Value	-6000 volts
Relative Maximum Value	+6000 volts over V_{low} voltage
Relative Minimum Value	V_{low} voltage
Input Connector	Kings 10KV, Rear Panel (+V IN)
Maximum Input Power	100 Watts (V_{HIGH} + V_{LOW} supplies)
INPUT DC VOLTAGE -V IN(V_{low})	
Source	External
Absolute Maximum Value	+6000 volts
Absolute Minimum Value	-6000 volts
Input Connector	Kings 10KV, Rear Panel (-V IN)
OUTPUT PULSE VOLTAGE	
Maximum Value	±6000 volts (V_{HIGH} - V_{LOW})
Minimum Value	0 volts
Means of Adjustment	Controlled By Power Supply Input Voltages
Output Connector	Kings 10KV, Rear Panel (OUTPUT)
GATE	
Gate Source	External
Gate Input	+5V ±1V into 50Ω
Gate Rise Time	<20ns
Gate Input Connector	Type BNC, Front Panel
OUTPUT PULSE ELECTRICAL CHARACTERISTICS (50pF load at end of 4 ft. RG-59 cable, 6000V)	
Pulse Rise and Fall Time	<60ns (10%-90%)
Pulse Width	<150ns to DC, controlled by input gate
Pulse Recurrence Frequency	Single Shot to 10KHz, controlled by input gate (1)
Droop	<1% into a capacitive load
Maximum Duty Cycle	Continuous
MONITOR OUTPUTS	
Voltage Monitor (V Mon)	2kV/V Into 1 MegΩ
Current Monitor (I Mon)	10A/V Into 50Ω

These specifications are measured driving a 50pF load connected with 4 feet of RG-58 cable, at 6000V output. However the PVX-4130 can drive loads of a few picofarads to several hundred picofarads of capacitance, limited by its maximum power dissipation capability(1) . At lower load capacitances and/or voltages less then 6000V, the PVX-4130 can operate at continuous pulse recurrence frequencies above 10KHz. The PVX-4130 can also drive resistive or inductive loads, within limitations. Contact DEI for additional information and applications assistance.

(1) The power dissipated in the PVX-4130 when driving a capacitive load is defined by the formula CV^2F, where C is the total load capacitance, including the capacitance of the load, interconnect cable, and the internal capacitance of the PVX-4130, V is the pulse voltage, and F is the pulse repetition frequency (or the total pulses per second). (For these calculations, the internal capacitance of the PVX-4130 is 100pF, and RG-58 cable is 30pf/foot.) Given the maximum dissipation of 100W, the maximum load capacitance, frequency and/or voltage at which the PVX-4130 can operate can be approximated using this formula. This formula also approximates the high voltage power supply requirements needed to drive a given load at a specific voltage and frequency. This formula is not applicable when driving resistive or inductive loads.

3.0 SAFETY

The high voltage 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 PVX-4130.

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 PVX-4130 is designed to operate from a power source that will not apply more than 240 volts AC 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 PVX-4130 is grounded through the grounding conductor of the AC power cord. **To avoid electrical shock, plug the PVX-4130 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 covers. **Do not operate the PVX-4130 while the covers are removed.** The covers do 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 output of the unit. 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 PVX-4130 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 PVX-4130 is turned on, or dangerous voltage is present in the chassis, assume it is possible to get a pulse on the output connector.

3.2 Servicing Safety Summary

The PVX-4130 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 PVX-4130 contains capacitors that are used as energy storage elements. When charged, these capacitors contain approximately 3 Joules of stored energy. This is sufficient energy to cause serious injury. **Assure that the AC power cord is disconnected from the driver. Verify that the capacitor bank is fully discharged, and 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 6000VDC and 240VAC or greater. Dangerous voltages, floating ground planes and energy storage exist at several locations in the PVX-4130. Touching connections and/or components could result in serious injury.

4.0 OPERATING CONSIDERATIONS

4.1 Output Cabling

The PVX-4130 is designed to drive capacitive loads with fast rise times. Since the current out of the GRX is limited, the lower the capacitance, the faster the rise time. Given fixed load characteristics, only the interconnecting cable type and length will vary the output capacitance.

The unit is supplied with a 4-foot length of Teflon-insulated RG-58 coaxial cable which has a capacitance of 30pF per foot. The unit is series terminated in the characteristic impedance of this cable, which is 50Ω. DEI recommends that the shortest length of cable possible be used to ensure the fastest possible rise times and best pulse fidelity.

4.2 Load Simulation

This unit was tested with a 50pF capacitive load connected to the output with 4 feet of RG-58 coaxial cable.

4.3 Trigger Input

An input trigger of +5V ±1V into 50Ω with a rise time of <20ns is required to gate on the PVX-4130. 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 50Ω before the trigger cable is attached to the PVX-4130 trigger input. The input trigger amplitude should be set using a 50Ω load (e.g. a 50Ω scope input) before connecting it to the PVX-4130. If the trigger input is greater than +5V into 50Ω , pulse stretching can occur.

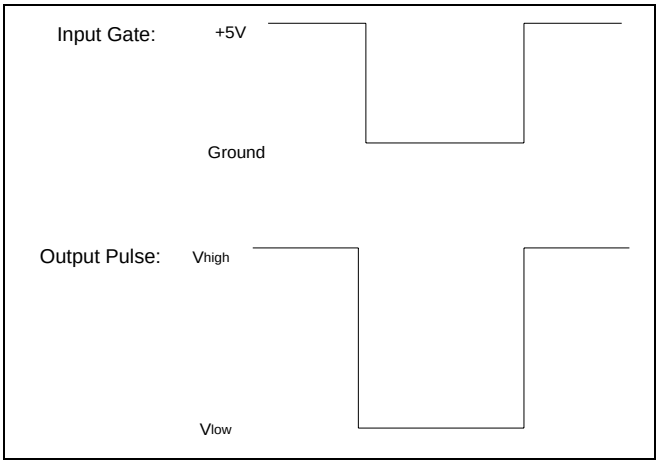
4.4 Pulse Voltages +V IN and -V IN

The PVX-4130 Pulser is rated at a maximum pulse output voltage of ±6000VDC. Proper precautions should be taken by the user to ensure that the maximum voltage is not exceeded.

4.5 Output Pulse Considerations

The PVX-4130 Pulser can generate single-ended output pulses from ground to +6000V or from ground to -6000V, and can also generate pulses originating from a voltage offset from ground. This offset can be from -6000V to +6000V, but the maximum power supply voltage differential (V_{high} - V_{low}) should never exceed 6000V. The V_{high} supply should always be equal to or greater than the V_{low} supply, but never greater than 6000V above the V_{low} supply. Therefore the V_{low} supply may be set to any voltage between -6000V and +6000V, and the V_{high} supply may be set to any voltage between -6000V and +6000V, but the voltage difference between V_{low} and V_{high} should never exceed +6000V. If the unit is operated with a single power supply (i.e. single-ended), the unused power supply input should be grounded.

When the input gate is high, the V_{high} supply is connected to the output. When the input gate is low, the V_{low} supply is connected to the output. Therefore the PVX-4130can be used to generate a negative-going pulse by logically inverting the input gate, so that the input gate is high until the unit is pulsed. When the input gate goes low, the V_{low} supply is connected to the output, thereby generating a negative going pulse (see the example in the figure below).



Generating a Negative Pulse with the GRX

4.6 Controls and Indicators

4.6.1 Power Switch and LED

The switch labeled "POWER" controls all AC power in the chassis. The LED also labeled “POWER” above the switch illuminates when AC power is turned on.

4.6.2 Output Switch and LED

The output switch enables and disables the pulse output. When the switch is on, the output is enabled, and the "OUTPUT ENABLED" LED above the switch is illuminated.

4.6.3 Gate Connector

The BNC connector labeled "GATE" is the input to gate the pulser. The input should be +5V into 50Ω, with a rise time less than 20ns. The output pulse width and frequency are controlled by the input gate's width and frequency.

4.6.4 Gated LED

The LED labeled "GATED" illuminates when a gate signal of the appropriate amplitude and width to gate the pulser is received. If the "GATED" LED is not illuminated, the PVX-4130 will not generate an output pulse.

4.6.5 Over Current LED

The LED labeled "OVER CURRENT" illuminates if the output pulse current exceeds 15A. If this LED illuminates, the pulse output will be inhibited for 6-7 milliseconds. If the LED illuminates continuously, the cause of the over current fault should be corrected before attempting to operate the pulser.

4.6.6 Control Error LED

The LED labeled "CONTROL ERROR" illuminates if the input gate frequency exceeds 10KHz. If this LED illuminates, the pulse output will be inhibited. If the LED illuminates, reduce the frequency of the input gate before attempting to operate the pulser.

4.6.7 Current Monitor

The BNC connector labeled "I MON" provides a 10A/V monitor of the output current. This monitor should be terminated into 50Ω, such as the 50 Ω input of an oscilloscope.

4.6.7 Voltage Monitor

The BNC connector labeled "V MON" provides a 2kV/1V monitor of the output current. This monitor should be terminated into 1 MegΩ, such as the 1 MegΩ input of an oscilloscope.

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 Electrical Installation

Standard units are shipped ready for use with a nominal 110-240VAC input.

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 Electrical Check

Before proceeding, please review the precautions in Section 3.

5.4.1 Power-Up

The unit should be powered up using the following procedures:

1. Before connecting the pulse generator to the PVX-4130, set up the pulse generator output to deliver a +5V pulse (±1V) into 50Ω, with a rep rate of approximately 500Hz, and a pulse width of 1μs.

2. Connect the positive output power supply to the rear panel connector labeled +V IN. Connect the negative output power supply to the rear panel KING'S 10KV connector labeled -V IN. For +6000V single-ended output, -V IN must be connected to ground. The power supply input should be grounded if no power supply is connected. Ensure that both power supplies are turned off.

3. Plug the power cord into the AC power input and turn on the front panel Power switch. The "POWER" indicator LED should turn on, indicating that the PVX-4130 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 pulse generator to the front panel BNC connector of the PVX-4130 labeled "GATE".

5. Connect an appropriate load to the rear panel output connector.

6. Monitor the voltage at the output, by connecting one end of a coax to the "V MON" BNC connector on the front panel and the other end to an oscilloscope with a 50Ω terminator.

7. Slowly turn up the high voltage power supplies. The PVX-4130 should produce an output pulse, with a pulse width and pulse recurrence frequency following that of the incoming trigger.

8. If there is no output from the PVX-4130, or the output is severely distorted, turn OFF the high voltage power supplies. Leave the PVX-4130 connected to the AC input without pulse voltage and with all connectors in place for approximately five minutes 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

This section provides basic operating instructions for the PVX-4130. Additional application information may be found in Section 7.0.

WARNING

1. To avoid personal injury, do not remove the covers. Do not operate the PVX-4130 while the covers are removed. The covers do not contain safety interlocks!

2. Do not remove the input or output cables while the driver is in operation. The PVX-4130 offers limited protection against shorts and arcs to ground, however never intentionally short-circuit the pulse voltage output of the pulser. If allowed to operate into a short for an extended period of time, damage to the unit, load and/or associated cabling may result. Failure to observe these precautions can result in potential electric shock to personnel, arcing, and damage to the connectors and system.

3. Pulsed power systems are capable of random triggering via transients and therefore when the PVX-4130 is turned on, or 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 5.3.1. When this is accomplished, the driver can be adjusted for the particular application through the following procedure:

1. Monitoring the output of the PVX-4130 on an oscilloscope using the internal voltage monitor or a high voltage probe connected to the output load, set the output amplitude of the PVX-4130 to the desired level by adjusting the output voltage of the high voltage power supplies.

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 PVX-4130. The output pulse voltage will follow the input trigger, but will not replicate in time the exact duration of the input trigger due to asymmetric system propagation delays.

6.2 Power-Down Procedures

1. Set the high voltage power supplies to zero.
2. Turn off the high voltage power supplies.
3. Turn off the PVX-4130 power switch.
4. Disconnect the AC power to the unit.

7.0 TROUBLESHOOTING

WARNING

The PVX-4130 contains capacitors that are used as energy storage elements. When charged, these capacitors contain approximately 3 Joules of stored energy. This is sufficient energy to cause serious injury. **Assure that the AC power cord is disconnected from the driver. Verify that the capacitor bank is fully discharged, and 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 6000VDC and 240VAC or greater. Dangerous voltages, floating ground planes and energy storage exist at several locations in the PVX-4130. Touching connections or components could result in serious injury.

7.1 Troubleshooting Procedures

Before attempting to service or troubleshoot the PVX-4130, review the servicing safety summary in Section 3.0.

The power MOSFETs utilized in the PVX-4130 are mounted on the printed circuit board. In the unlikely event that the MOSFETs 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.

SYMPTOM	SOLUTIONS
"POWER" LED Does Not Illuminate	• AC power not plugged in. • Fuse(s) are blown. See fuse replacement instructions in Section 7.1.1
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 high voltage. Check power supplies • 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 driver, use only the fuse type listed on the rear panel. Fuse replacement should be performed by qualified personnel only. **Assure that the AC power cord is disconnected from the driver.**

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 PVX-4130 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 PVX-4130. FAILURE TO DO SO VOIDS THE WARRANTY.

8.1 Over-Current Failure

When the output is shorted, the PVX-4130 can deliver in excess of 30A of current (depending on cabling, pulse power supply setting, etc.). A current pulse of this magnitude is in excess of the driver's specifications. The PVX-4130 offers limited protection against shorts and arcs to ground, however if allowed to operate into a short for an extended period of time, damage to the unit, load and/or associated cabling may result.

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 MERCHANTIBILITY 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.