

Directed Energy

DEI



PVX-4140 B

±3500 V Pulse Generator

Operating Manual



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1.0 GENERAL DESCRIPTION

The DEI PVX-4140 B is a solid-state high-voltage pulser designed to drive capacitive loads such as grids and deflection, reflection and acceleration plates.

The instrument features an output voltage swing of up to 3500 V, peak current of up to 25 A, and continuous current of up to 0.1 A. It can output DC as well as very flat voltage pulses into a capacitive load.

The PVX-4140 B generates single-ended output pulses from ground to +3500 V or from ground to -3500 V; it can also generate pulses originating from a voltage offset from ground. The offset can range from -3500 V to +3500 V with a maximum differential of 3500 V.

2.0 SPECIFICATIONS

Reference the PVX-4140 B datasheet on the website for the specifications:

<https://directedenergy.com>

3.0 SAFETY

The high voltage capability of this instrument dictates caution when operating it. The following is a summary of general safety precautions that must be observed during all phases of operation of the PVX-4140 B.

WARNING

- **Risk of lethal electric shock. Do not touch the output or load while the PVX-4140 B is operating. This instrument produces LETHAL levels of electric current at its output.**
- DO NOT OPERATE THIS INSTRUMENT UNLESS ANOTHER PERSON, CAPABLE OF RENDERING FIRST AID OR RESUSCITATION, IS PRESENT.
- SAFE AND PROPER OPERATION OF THIS INSTRUMENT IS THE RESPONSIBILITY OF THE USER.
- The cover should NEVER be removed. There are NO user-serviceable items inside.
- Always turn the high voltage power supplies and the PVX-4140 B OFF prior to working with the load or input and output cables.
- Do not remove the input or output cables while the instrument is in operation. Never short-circuit the output. Failure to observe these precautions can result in potential electric shock to personnel, arcing, and damage to the connectors and the instrument.

- Pulsed power systems are capable of random triggering via transients. Whenever the PVX-4140 B is turned on, or voltage is present in the chassis, assume a pulse can appear on the output connector.

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.

3.1 Power Source

The PVX-4140 B 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.

3.2 Grounding

The PVX-4140 B is grounded through the grounding conductor of the AC power cord. **To avoid electrical shock, plug the PVX-4140 B into a properly wired receptacle before making connection to any input or output connectors.** Use only a power cord that is in good condition.

3.3 General Operating Precautions

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

4.0 OPERATING CONSIDERATIONS

4.1 Output Cabling

The PVX-4140 B is designed to drive capacitive loads with fast rise times. Since the output current is limited, increasing the load capacitance lengthens the rise time. If the load is fixed, only the type and length of the interconnecting cable will vary the output capacitance.

The instrument is supplied with a 6-foot length of RG-59 coaxial cable that has a capacitance of 21.5 pF per foot. The instrument is series-terminated in the characteristic impedance of the cable (75 Ω). DEI recommends using the shortest possible cable to ensure the fastest rise times and best pulse fidelity.

4.2 Load Simulation

The PVX-4140 B was tested with a 50 pF capacitive load connected to the output via 6 feet of RG-59 coaxial cable.

4.3 Gate Input

A logic level of +5 V \pm 1 V into 50 Ω with a rise time of <20 ns is required to gate the PVX-4140 B. Departure from these values can result in a loss of performance. These requirements are met by any high-quality, logic-level pulse generator. The source should be configured to +5 V \pm 1 V into 50 Ω before the cable is attached to the PVX-4140 B Gate input. The amplitude of the gate pulse should be set using a 50 Ω load (e.g., a 50 Ω scope input) before connecting it to the PVX-4140 B. If the gate pulse is greater than +5 V into 50 Ω , pulse stretching can occur.

4.4 High Voltage Inputs

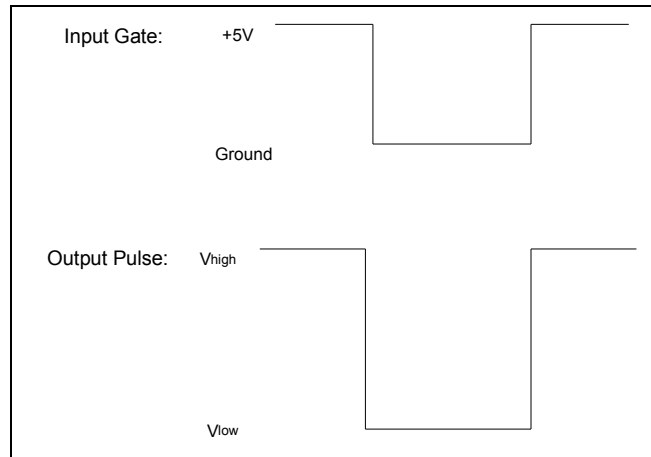
The absolute maximum rating for the high voltage inputs is \pm 3500 V. In addition, the +HV Input must never be greater than +3500 V above the -HV Input. Precautions should be taken to ensure that these maximum voltages are not exceeded.

4.5 Output Pulse Considerations

The PVX-4140 B can generate single-ended output pulses from ground to +3500 V or from ground to -3500 V. It can also generate pulses originating from a voltage offset from ground. This offset can be from -3500 V to +3500 V, but the +HV Input should always be equal to or greater than the -HV Input and never greater than +3500 V above the -HV Input.

If the instrument is operated with a single power supply for unipolar pulses, the unused high voltage input must be grounded.

When the Gate input is high, the +HV Input is switched to the output. When the Gate input is low, the -HV Input is switched to the output. The PVX-4140 B can generate a negative-going pulse by logically inverting the Gate input so that the Gate input is high until a pulse is generated. When the Gate input goes low, the -HV Input is switched to the output, thereby generating a negative going pulse (see the figure below).



Generating a Negative Pulse with the PVX-4140 B

4.6 Controls and Indicators

4.6.1 Power Switch and LED

The power switch on the rear panel controls all AC power in the instrument. The Power LED on the front panel illuminates when AC power is turned on.

4.6.2 Enable Button and LED

The Enable button enables and disables the pulse output. The Output Enabled LED illuminates when the output is enabled.

4.6.3 Gate Connector

Logic-level pulses at the Gate input control the output. The input requirements are +5 V into 50 Ω with a rise time less than 20 ns. The output pulse follows the Gate input signal's pulse width and frequency.

4.6.4 Gated LED

The Gated LED illuminates when a gate signal of the appropriate amplitude and width is received. If the Gated LED is not illuminated, the PVX-4140 B will not generate an output pulse.

4.6.5 Over Current LED

The Over Current LED illuminates if the output pulse current exceeds either the positive or negative current limit value.

NOTE: Depending on the value of high voltage, the over current limit may or may not be exceeded even when the load is shorted.

If the Over Current LED illuminates when the PVX-4140 B is in Auto Reset mode (see Section 4.7), the pulse output will be inhibited for 6 to 7 milliseconds. If Auto Reset is not enabled, the instrument must be manually reset. (A manual reset is accomplished by pressing the Enable button twice: Once to reset the fault, and the second time to enable the output. The instrument may also be reset via the remote reset function. See section 4.7.)

If the Over Current LED illuminates continuously, the cause of the over current fault should be corrected before attempting to operate the instrument.

4.6.6 Control Error LED

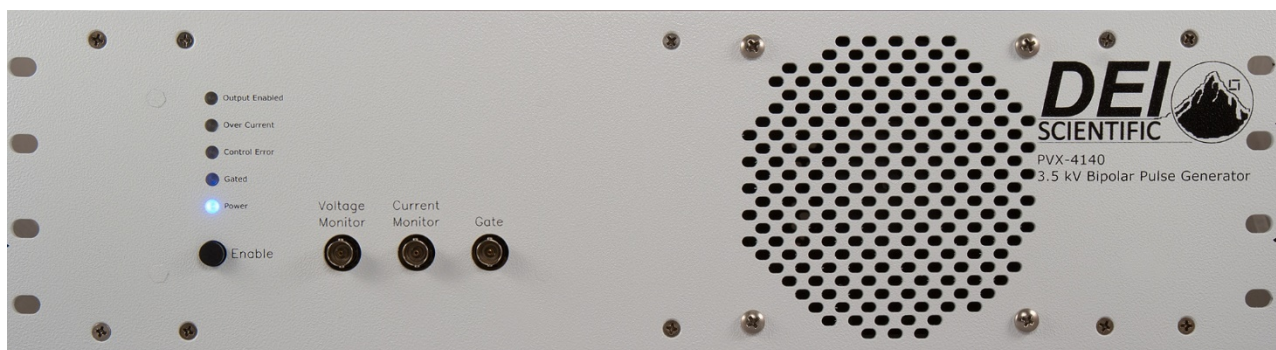
To permit burst mode operation, the Control Error LED is not used in this instrument model.

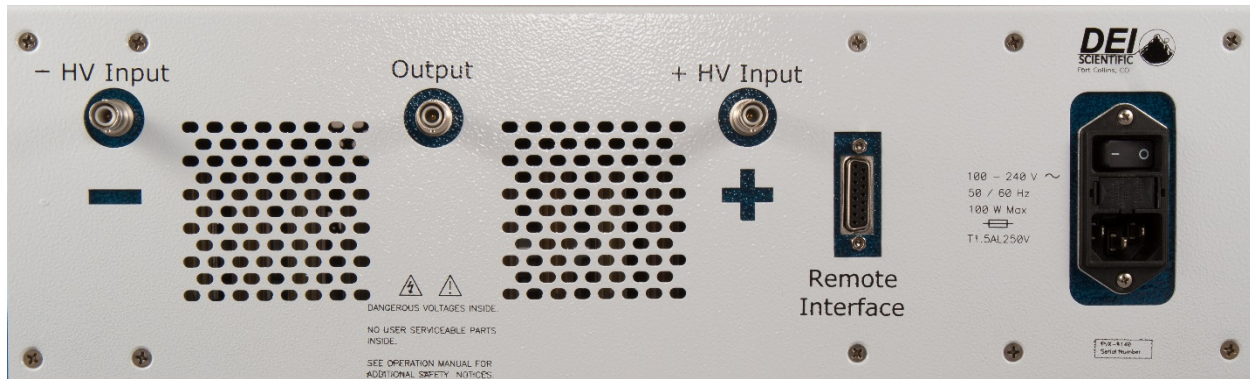
4.6.7 Current Monitor

The Current Monitor BNC connector provides a 10 A per V scaled version of the output current for display on an oscilloscope. The scope input impedance should be 50 Ω .

4.6.8 Voltage Monitor

The Voltage Monitor BNC connector provides a 1 V per 1000 V scaled version of the output pulse voltage for display on an oscilloscope. The scope input impedance should be 1 M Ω .

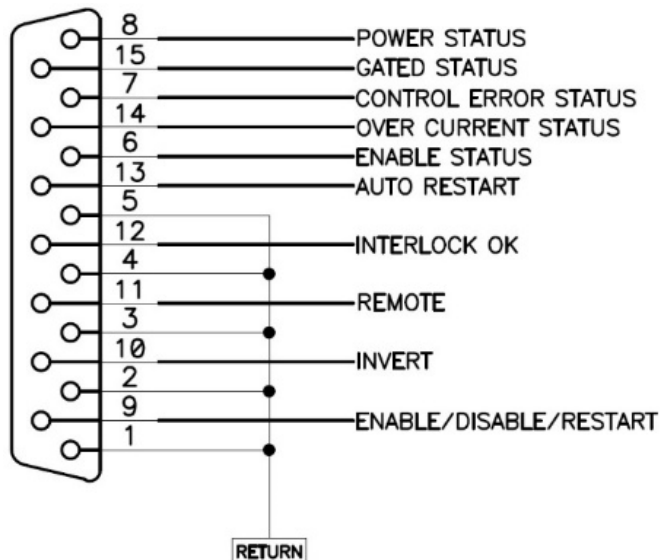




4.7 Remote Control

The PVX-4140 B can be operated via remote control. The following table provides the pinout of the Remote Interface connector (DA-15 socket) on the rear panel.

<u>PIN</u>	<u>FUNCTION</u>	<u>DESCRIPTION</u>
1	GND	Ground
2	GND	Ground
3	GND	Ground
4	GND	Ground
5	GND	Ground
6	<u>Enable Status</u>	Output: Active low, open drain, 24 mA maximum ON, 24 V DC maximum OFF
7	<u>Control Error Status</u>	Output: Active low, open drain, 24 mA maximum ON, 24 V DC maximum OFF (not used)
8	<u>Power Status</u>	Output: Active low, open drain, 24 mA maximum ON, 24 V DC maximum OFF
9	Enable	Input: Low-to-high transition to enable, disable, reset
10	Invert	Input: Pull low to invert the Gate input
11	Remote	Input: Pull low for remote operation
12	Interlock	Input: Pull low to satisfy the interlock
13	Auto Reset	Input: Pull low to enable auto reset
14	<u>Over Current Status</u>	Output: Active low, open drain, 24 mA maximum ON, 24 V DC maximum OFF
15	<u>Gated Status</u>	Output: Active low, open drain, 24 mA maximum ON, 24 V DC maximum OFF



The inputs on the Remote Interface connector are internally pulled high. For remote operation, pull the Remote pin low. This disables the front panel Enable button and prevents local operation.

NOTE: The Enable, Interlock, Invert, and Auto Reset inputs are always active, regardless of the state of the Remote input.

If the Enable input is momentarily pulled low, the instrument will be enabled, or a fault will be cleared, on the rising edge.

If the Invert input is pulled low, gate pulses are inverted internally. The output pulse will be inverted from that of the Gate input.

WARNING: If the system is wired for remote control, the local mode can be overridden by the remote user and the system can be enabled remotely. This can create a dangerous scenario: One person may be working on the load, needing to turn the instrument on and off locally, while another person working remotely could inadvertently turn it ON. For this reason, it is recommended to completely turn the high voltage power supplies and the instrument OFF when servicing the load.

The Interlock input (pin 12) must be connected to Ground (pin 4) in order to satisfy the interlock circuit as shipped from the factory. If the Interlock pin is disconnected, the user will not be able to enable the output. The interlock feature can be used as part of a safety circuit in which the Interlock input is pulled low to enable the instrument and unconnected to disable it.

The Auto Reset input allows the user to choose how to clear the faults. When the Auto Reset input is low, the instrument resets itself 6 ms after a fault occurs. When the Auto Reset input is unconnected, the user must reset faults manually.

A fault can be cleared manually by either of two methods:

- 1) On the front panel, press the Enable button once to reset the fault, then a second time to enable the output.
- 2) On the Remote Interface connector, pull the Enable input low once to reset the fault, then a second time to enable the output.

The status outputs (pins 6, 8, 14, and 15) follow the states of the front panel LEDs. All are open drain and require external pull up resistors (1 kΩ or larger) to a power supply of up to +24 V DC.

5.0 PREPARATION FOR USE

5.1 General

After unpacking, perform an initial inspection and preliminary electrical check to ensure the instrument is in good working order. Notify the carrier immediately if damage is found. Direct any repair problems to the service department listed at the end of this document.

5.2 Initial Inspection

1. Inspect the instrument for exterior mechanical damage.
2. Inspect the input power cord and input power module for damage.

5.3 Electrical Installation

Standard PVX-4140 Bs are shipped ready for use with a nominal 110-240 VAC input.

5.3.1 Input Power Cord

The input power cord terminates externally in a three-prong polarized plug. The 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 instrument. The instrument 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 PVX-4140 B should be powered up using the following procedures:

1. Insert the supplied DA-15 plug into the rear panel socket. As configured by the factory, the plug has pins 4 and 12 jumpered to satisfy the interlock, and pins 5 and 13 jumpered to enable auto reset. Because pin 11 (Remote) is not grounded, remote operation is disabled. **This plug must be installed in order to satisfy the interlock circuit. If it is not installed, the instrument cannot be enabled.** To operate the PVX-4140 remotely, or to use an external interlock, wire the DA-15 connector accordingly (see the “Remote Control” section above).
2. **WARNING:** If the system is wired for Remote Control, the local mode can be overridden by the remote user. For this reason, it is recommended to power off the high voltage power supplies and when servicing the instrument.

3. Before connecting the pulse generator to the PVX-4140 B, set up the pulse generator output to deliver a $+5\text{ V} \pm 1\text{ V}$ pulse into $50\ \Omega$. Use a repetition rate of approximately 500 Hz and a pulse width of 1 μs .
4. Ensure that both high voltage power supplies are OFF.
5. Connect the positive power supply to the rear panel SHV connector labeled +HV Input. Connect the negative power supply to the rear panel SHV connector labeled -HV Input. For positive-only output pulses, ground the -HV Input. For negative-only output pulses, ground the +HV Input.
6. Connect an appropriate load to the rear panel SHV output connector.
7. The output pulse can be displayed on an oscilloscope two ways. One is by connecting an appropriate high voltage probe to the output load, utilizing an appropriate attenuator if necessary. The second and easier way is to use the front panel Voltage Monitor (set the scope input impedance to $1\text{ M}\Omega$). Please note that the rise and fall times are from the launch point of the pulse and may differ slightly from the ones displayed at the load.
8. Plug the power cord into the AC power input and turn on the rear panel Power switch. The Power LED should illuminate, indicating that the PVX-4140 B is operational. If this does not occur, unplug it from AC power and refer to the Troubleshooting Section of this manual.
9. Connect a coaxial cable from the pulse generator to the Gate input.
10. NOTE: The PVX-4140 B powers up in a faulted condition. Once the pulse generator is enabled, the fault clears within 5 seconds.
11. Enable the PVX-4140 B by pressing the Enable button.
12. Slowly increase the high voltage power supplies until the desired load voltage is reached. The PVX-4140 B output pulses follow the width and repetition rate of the Gate input signal.
13. If there is no output from the PVX-4140 B, or the output is severely distorted, turn OFF the high voltage power supplies. Leave all connections (including the AC power cord) in place for approximately five minutes to bleed off the stored energy. Disconnect the AC power refer to the Troubleshooting Section of this manual.

6.0 OPERATING INSTRUCTIONS

This section provides basic operating instructions for the PVX-4140 B. Additional application information may be found in Section 7.0.

WARNING

1. There are NO user serviceable items inside this instrument. The cover should NEVER be removed.
2. Do not remove the input or output cables while the instrument is in operation. Never short-circuit the output of the instrument. 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. When the PVX-4140 B 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 instrument should be powered up using the procedures detailed in the Section above. When this is accomplished, it can be adjusted for the particular application through the following procedure:

1. Monitor the output of the PVX-4140 B on an oscilloscope utilizing a high voltage probe connected to the load, or with a coax attached to the Voltage Monitor output on the front panel. Set the output amplitude of the PVX-4140 B to the desired level by adjusting the output voltage of the high voltage power supplies.
2. Set the output pulse width and pulse repetition frequency by varying the controls of the Gate input pulse generator. The output pulse width should be set by monitoring the output of the PVX-4140 B. The output pulse voltage will follow the gate input, but will not replicate in time the exact duration of the Gate input due to the system propagation delay.

6.2 Power-Down Procedures

1. Set the high voltage power supplies to zero.
2. Turn the high voltage power supplies OFF.
3. Turn the PVX-4140 B power switch OFF.
4. Allow the instrument to bleed off the stored energy (approximately five minutes).
5. Disconnect the AC power to the instrument.

7.0 TROUBLESHOOTING

7.1 Troubleshooting Procedures

Before attempting to service or troubleshoot the PVX-4140 B, review the safety summary above.

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

- Power LED does not illuminate
 - AC power not plugged in
 - Fuse(s) are blown
- Cannot enable output
 - External remote interlock circuit is not satisfied
- No Output Pulse
 - Output is not enabled
 - External remote interlock circuit is not satisfied
 - No gate input
 - Gate input pulse voltage too low: Increase voltage
 - Gate input pulse width too narrow: Increase width
 - Gate input pulse frequency too high: Reduce frequency
 - No high voltage: Check HV supplies for correct operation
 - Output not connected correctly: Check all cables and connections
 - Instrument is damaged: Contact DEI customer service

7.1.1 Fuses

To avoid fire hazard or damage to the instrument, use only the fuse types listed on the rear panel. Fuse replacement should be performed by qualified personnel only.

8.0 SYSTEM FAILURE MODES

The PVX-4140 B 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-4140 B. FAILURE TO DO SO VOIDS THE WARRANTY.

8.1 Over-Current Failure

Depending on the value of load voltage, the overcurrent limit may or may not be exceeded even when connected to a shorted load. Typically, the output voltage must be greater than 733 V. If the output voltage is in excess of 733 V and the load is shorted, then the Over Current LED should illuminate. Internally, this indicates that the

output pulse current has exceeded either one of the two internal current limits, one for positive pulses and one for negative pulses. If allowed to operate into a short for an extended period of time, damage to the instrument, load, and/or associated cabling may result. If this LED illuminates, and the instrument is in Auto Reset mode (See Section 4.7) the pulse output will be inhibited for 6-7 milliseconds. If Auto Reset is not enabled, the instrument must be manually reset. This is done by pressing the Enable button twice: Once to reset the fault, and the second time to enable the output. The instrument may also be reset through the remote reset function - See section 4.7. If the LED illuminates continuously, the cause of the over current fault should be corrected before continuing operation.

9.0 WARRANTY

Directed Energy, Inc. (DEI) warrants equipment it manufactures to be free from defects in materials and factory workmanship under conditions of normal use and agrees to repair or replace any standard product that fails to perform as specified within one year after date of shipment to the original owner. OEM, modified, and custom products are warranted, as stated above, for ninety (90) days from date of shipment to original owner. This Warranty shall not apply to any product that has been:

- I. Repaired, worked on, or altered by persons unauthorized by DEI in such a manner as to injure, in DEI's sole judgment, the performance, stability, or reliability of the product;
- II. Subjected the product to misuse, neglect, or accident; or
- III. Connected, installed, adjusted, or used otherwise than in accordance with instructions furnished by DEI.

DEI reserves the right to make any changes in the design or construction of its products at any time, without incurring any obligation to make any change whatever in instruments previously delivered.

DEI's sole obligation, and buyer's sole remedies, under this agreement shall be limited to a refund of the purchase price, or at DEI's sole discretion, to the repair or replacement of products in kind that prove, to DEI's satisfaction, to be defective, when returned to the DEI factory, transportation prepaid by the buyer, within the warranty period. DEI shall in no way be liable for damages consequential or incidental to defects in its products, for failure of delivery in whole or in part, for injuries resulting from its use, or for any other cause.

Returns must be preauthorized and accompanied by a DEI return authorization number.

The foregoing states the entire warranty extended by DEI and is given and accepted in lieu of 1) any and all other warranties, expressed or implied, including but not limited to the implied warranties of merchantability and fitness for any particular purpose, and 2) any obligation, liability, right, claim or remedy in contract or tort.

10 Factory Service

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

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